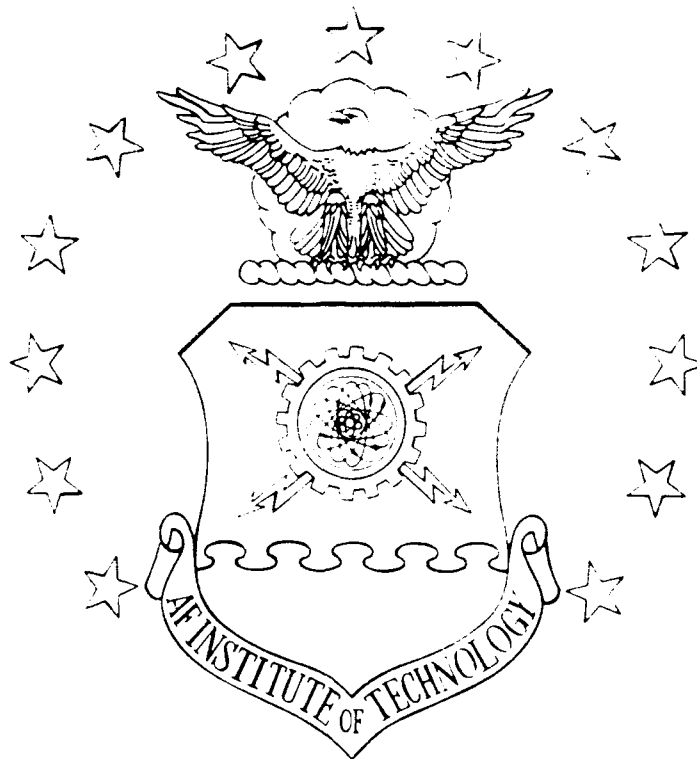AD-A230 557

AN ANALYSIS OF THE
ADVANCED CRUISE MISSILE
SYSTEM PROGRAM OFFICE
ENGINEERING CHANGE PROPOSAL
PROCESS

THESIS

Jeffery S. Robertson, Captain, USAF

AFIT/GSM/ENC/90S-23

DEPARTMENT OF THE AIR FORCE

AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

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AN ANALYSIS OF THE ADVANCED CRUISE MISSILE

SYSTEM PROGRAM OFFICE ENGINEERING CHANGE PROPOSAL PROCESS

THESIS

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Systems Acquisition Management

Jeffery S. Robertson, B.S.

Captain, USAF

September 1990

Approved for public release; distribution unlimited

Preface

The purpose of this study was to analyze the Engineering Change Proposal (ECP) process in the Advanced Cruise Missile (ACM) System Program Office (SPO). The ACM is critical to maintaining a level of strategic deterrence for the United States, and the ECP process was perceived to be untimely. For these two reasons I chose to analyze the ECP process in the ACM SPO to develop recommendations for improving its timeliness. I statistically analyzed actual SPO process time data and the results of a survey questionnaire administered to ACM SPO personnel, and I concluded that the untimeliness of certain process steps was a symptom of a lack of effort or concern on the part of the ACM SPO personnel during the review of the Technical Change Package (TCP), a precursor document to the ECP. The time needed to perform rework was found to be significant, and I recommended that the SPO institute programs to increase the awareness of the need for improvement in this area.

This thesis could not have been completed without the help from others. First, Professor Daniel Reynolds provided untiring patience, tremendous assistance, and wonderful guidance throughout the thesis process. Personnel in the ACM SPO also deserve credit for their assistance. Robert Connolly and Marilyn Judd provided outstanding technical assistance, Doug Jones invited me to participate on the Critical Process Improvement Team, and Col Bolton and Lt Col Hemmig sponsored my effort in the SPO. Last, but certainly not least, my wife Roxanne was a tremendous help to me through the long days and nights that I spent preparing this report.

<div align="right">Jeffery S. Robertson</div>

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AFIT/GSM/ENC/90S-23

Abstract

This study investigated the engineering change proposal (ECP) process in the Advanced Cruise Missile (ACM) System Program Office (SPO). Specifically, efforts were geared toward verifying the process untimeliness and identifying the specific causes of the untimeliness. Also, a survey questionnaire was analyzed to assist in the development of conclusions about the problems with the ECP process. Specific process steps were identified as untimely; however, the major conclusion was that the personnel in the ACM SPO were not taking advantage of the opportunity to review the Technical Change Package (TCP), a preliminary copy of the ECP. By doing so, the SPO perhaps could have produced better quality ECPs which the approval authorities could have approved as written. Instead, because of content and documentation errors, the ECPs had to be deferred or approved with comments, forcing the SPO to perform additional process steps which added significantly to overall processing time required for eventual approval. The recommendation was made for the SPO to educate the personnel about the importance of an adequate TCP review, encourage improvement through the adoption of an awards program, and take steps to educate those personnel in the SPO who need training.

AN ANALYSIS OF THE ADVANCED CRUISE MISSILE SYSTEM PROGRAM

OFFICE ENGINEERING CHANGE PROPOSAL PROCESS

I. Introduction

General Background Information

Global Scenario. Since the end of World War II the Soviet Union
has been the only nation with the capability to threaten the national
survival of the United States (8:1). Because of this, the United States
has focused its national strategy to counter this capability (8:1).
Furthermore, the United States and the Soviet Union support different
ideologies, with the Soviet Union supporting the spread of communism and
the United States trying to contain the spread (26:1-5). Although the
two world powers have fought against each other's ideologies indirectly,
in Korea and Vietnam for example, they have not been involved in a
direct exchange of fire on a major scale. Why not? After all, both
countries possess the capability to destroy each other's industrial base
(25:1). Perhaps the two have not exchanged direct fire because of the
development and implementation of effective national security strate-
gies (NSS) by the United States presidential administrations since World
War II. From President Truman's policy of "Containment" to Eisenhower's
"Massive Retaliation" and Kennedy's and Johnson's "Mutually Assured
Destruction" (MAD) policies, the United States relied heavily on its
nuclear arms superiority over the Soviet Union to deter hostile actions
from it (26:1-3). However, because of an escalating growth in the nuc-

lear arms capabilities of the Soviet Union, the presidential administrations from Nixon and on have relied on a "Realistic Deterrence" NSS focusing on detente and preplanned and proportional nuclear responses to aggressive behavior (26:3-5). (Note: although President Reagan's NSS was named "Flexible Response," it retained the essential characteristics of the former Realistic Deterrence strategy (26:5).) These strategies have remained fairly constant through the years, despite the changes in the names, and they place heavy emphasis on deterrence to war through the availability of effective strategic nuclear forces (26:4-5).

The United States' Efforts. With the evolution of the United States national security strategy, to include not only "assured destruction" but also deterrence of limited nuclear attacks, the development of effective strategic offensive forces has been crucial (26:1). Indeed, "maintaining stable nuclear deterrence vis a vis the Soviet Union will depend on ... a modernized mix of nuclear systems that hold critical Soviet assets at risk" (8:3). This focus has resulted in the development of strategic nuclear ballistic missiles, air- and sea-launched nuclear cruise missiles, and the delivery and command and control systems which get them to where they need to go (25:1).

Furthermore, the United States has developed a strategic deterrence strategy to magnify its overall deterrent capability (25:2). This strategy consists of a focus on a TRIAD of weapons and delivery methods, including land-launched intercontinental ballistic missiles (ICBMs), submarine-launched ballistic missiles, and manned bombers which use nuclear bombs and air-launched cruise missiles (25:2). The three different legs of the TRIAD offer different advantages, plus the overall advantage

of forcing the Soviet Union to spend resources to defend against all

three (25:2). Land-based missiles are very accurate, have a high alert

rate, plus other advantages, but they cannot be overtly displayed as a

show of force--once they are launched they cannot be called back (25:2).

Likewise, submarine-launched ballistic missiles are accurate, and they

are the most survivable element of the TRIAD [unless the submarine can

be found before its missiles are launched] (25:4-5). Submarines, how-

ever, are not very suitable for use as a show of force and will, since

their mission is to remain in hiding (25:5). These two missile systems

leave a gap in capability that is filled by manned strategic bombers

(25:5). Indeed,

> Manned aircraft provide the highest measure of controllability and
> flexibility--the capability to respond to a wide variety of un-
> foreseen and rapidly changing circumstances. They can be launched
> for survival or a show of force or intent and can be recalled if
> execution is not directed. Manned aircraft can hunt out and
> destroy targets that cannot be located precisely in advance....
> They can react immediately to redirection, exploit fleeting
> advantages, and execute a broad range of missions. They offer the
> vital power of human observation and evaluation. (25:2)

Moreover, using guided cruise missiles (ALCMs), manned bombers have the

"capability to deliver massive firepower at long ranges" (25:6).

> The [ALCM] is a small, unmanned, winged air vehicle capable of
> sustained subsonic flight following launch from a carrier air-
> craft. It has a turbofan engine and a nuclear warhead and is
> programmed for precision attack on surface targets. When launched
> in large numbers, each of the missiles would have to be countered,
> making defense against them both costly and complicated. Addi-
> tionally, by diluting defenses, the ability of manned aircraft to
> penetrate to major targets is improved. Small radar signature and
> low-level flight capability enhance the missile's effectiveness.
> (31:156)

However, cruise missiles and manned aircraft are not immune to advance-

ments in defenses, especially the recent advancements made by the Soviet

Union.

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The Soviet Union's Efforts. Meanwhile, the Soviet Union has developed not only their own TRIAD, but also countermeasures to United States capabilities. These countermeasures include anti-aircraft and anti-cruise missile defensive systems around their political and industrial centers. The Los Angeles Times reported on August 7, 1983 that "Soviet air defenses, already the world's most advanced, are steadily improving, according to 'Soviet Military Power,' a Defense Department document released last March" (29:28). Furthermore,

> [Soviet] airborne radar can find a present-generation cruise missile no matter how low it flies or how much it bobs and weaves. The Soviets' Foxhound A fighter aircraft is said to have this "look-down/shoot-down" capability and Soviet versions of the huge American AWACS radar surveillance planes, with even better detection capability, are said to be improving. Another Soviet threat is the SA-10, a surface-to-air missile that might be able to knock down a slow-flying cruise missile "at any altitude," according to "Soviet Military Power." (29:28)

To counter these advancements by the Soviet Union, the United States has chosen to produce and field advancements of its own so that it may achieve one of its goals (8:3). What goal is important enough to the United States that it would be willing to spend large amounts of resources to achieve?

An Overall Goal. A stated goal of the United States is to maintain peace with the Soviet Union (26:1-5). A means by which this goal can be achieved is to continue to develop and deploy weapons which support the three legs of the TRIAD so that an effective deterrent capability continues to exit (25:1). The overall goal as stated here assumes that war between the United States and the Soviet Union is and will always be less desirable than peace. Also, as long as the Soviet Union is swayed toward maintaining peace because of our nuclear weapons,

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then a means to maintain that peace is through the continued development and deployment of these types of weapons.

The Overall Requirement. So, based on the above assumptions, the United States is required to have effective deterrent forces including land-, sea-, and air-based nuclear weapons which are, in the eyes of the Soviet Union, powerful, accurate, and able to reach their targets (8:3). Recall from the discussion above that the United States's land-and sea-based systems are relatively more accurate and more survivable than air-based systems, but cannot be used efficiently as a show of force and will (25:2,5). Also, because of continuing improvements in Soviet Union's anti-aircraft and anti-cruise missile defensive systems, the United States has decided to meet the overall need by focusing its attention on improving the air-based leg of the TRIAD in an effort to deploy a newer weapon system which will be more survivable than the older (31:156). This older weapon is the Air-Launched Cruise Missile (ALCM), which was first fielded in 1980 (3:4). The newer weapon is the Advanced Cruise Missile (ACM) (3:3). The United States initiated a development program for the ACM in 1983, with the intent that a more survivable, advanced [technology] cruise missile, would replace the older generation ALCM (31:156). Hence, to meet the need, a major requirement was born to develop and deploy an Advanced Cruise Missile that will survive the Soviet defensive systems, reach the target, and detonate. The flow from overall goal to the major requirement to deploy the ACM is shown in Figure 1. Furthermore, Figure 2 continues the train of thought from the establishment of the ACM SPO goal to a specific ACM SPO requirement.

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                    ┌─────────────────────────┐
                    │     OVERALL  GOAL        │
                    ├─────────────────────────┤
                    │ Peace With the Soviet Union │
                    └─────────────────────────┘
                                │
                                ▼
                    ┌─────────────────────────┐
                    │   OVERALL  REQUIREMENT   │
                    ├─────────────────────────┤
                    │ Effective Deterrent Forces │
                    └─────────────────────────┘
                                │
                                ▼
                    ┌─────────────────────────┐
                    │     OVERALL  NEED        │
                    ├─────────────────────────┤
                    │ Modernize Cruise Missiles │
                    └─────────────────────────┘
                                │
                                ▼
            ┌─────────────────────────────────────┐
            │         MAJOR  REQUIREMENT          │
            ├─────────────────────────────────────┤
            │ Develop and Deploy Advanced Cruise Missiles │
            └─────────────────────────────────────┘
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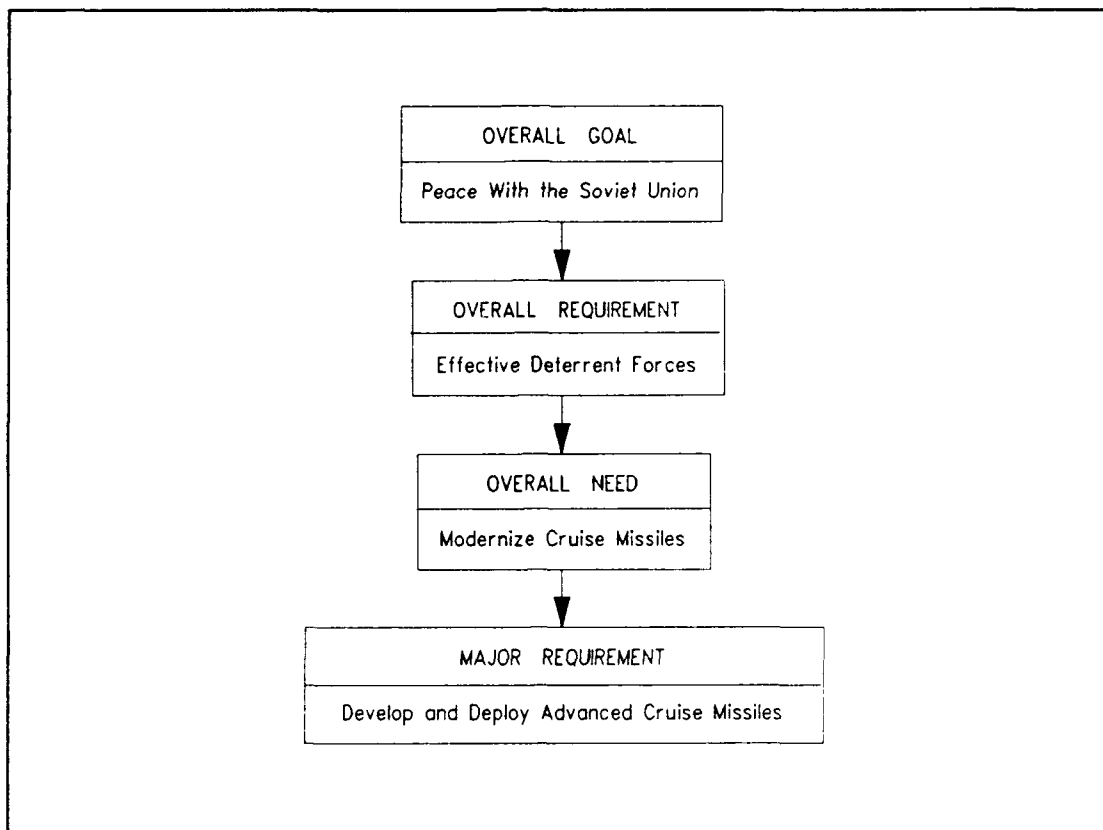
Figure 1.   Flow from Overall Goal to Major Requirement

ACM SPO Goal and Requirement

To support this major requirement, the Advanced Cruise Missile
(ACM) System Program Office (SPO) has adopted goals that stress the need
to "provide the User with a system that meets all stated requirements"
[including timely hardware deliveries] in a cost-effective manner
(30:3). Indeed, the ACM SPO has been tasked with the responsibility of
performing the necessary weapons system acquisition steps to make this
requirement a reality (10:4-8). These acquisition steps stress the
importance of basing decisions on the tradeoffs between the aspects of
cost, schedule, performance, and logistics supportability (19:10).
Since these aspects must be balanced, it follows that the ACM SPO needs

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                    ┌──────────────────────────┐
                    │      MAJOR SPO GOAL       │
                    ├──────────────────────────┤
                    │ Develop and Deliver ACMs to SAC │
                    └──────────────────────────┘
                                 │
                                 ▼
              ┌─────────────────────────────────────┐
              │          SPO REQUIREMENT            │
              ├─────────────────────────────────────┤
              │ Balance Cost, Performance, Logistics │
              │         Emphasize Schedule           │
              └─────────────────────────────────────┘
                                 │
                                 ▼
                    ┌──────────────────────┐
                    │      SPO NEED         │
                    ├──────────────────────┤
                    │   Timely Processes    │
                    └──────────────────────┘
                                 │
                                 ▼
                 ┌──────────────────────────┐
                 │   SPECIFIC REQUIREMENT    │
                 ├──────────────────────────┤
                 │     Timely ECP Process    │
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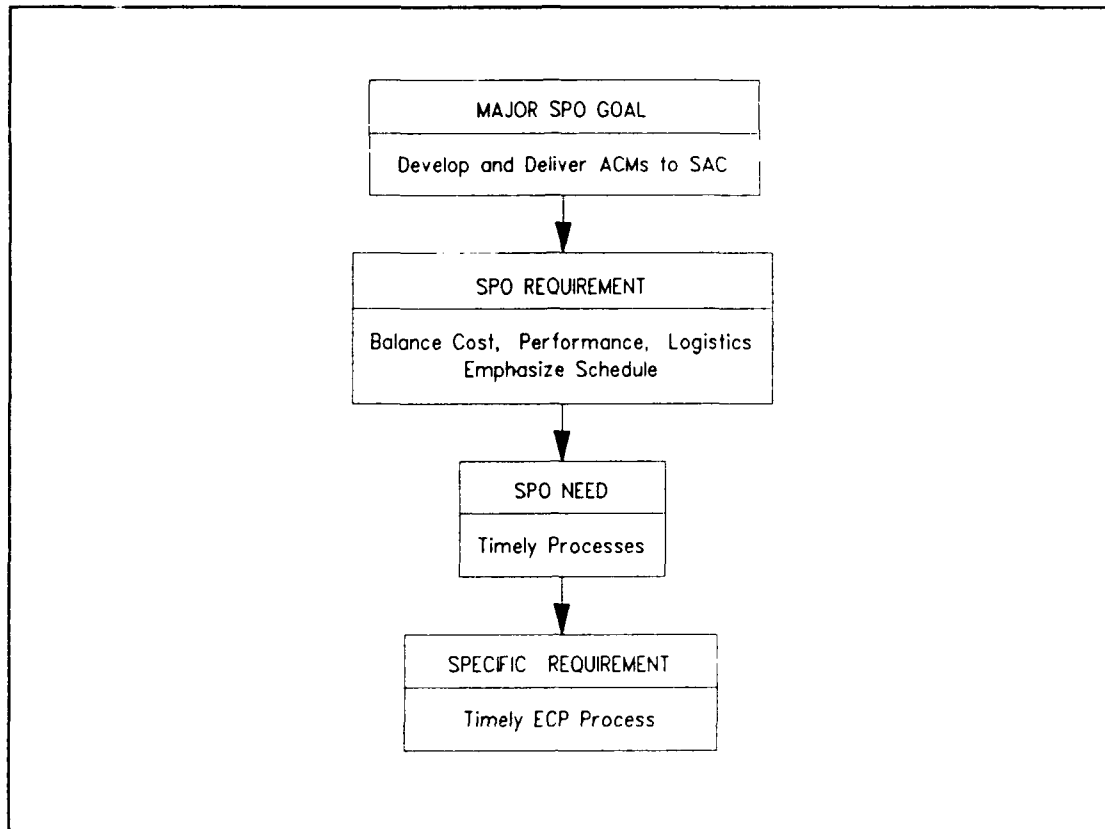
Figure 2. Flow from Major SPO Goal to Specific Requirement

to have timely and efficient internal processes which do not impact

these aspects. Indeed, the ACM SPO management would perhaps be

concerned about the efficiency and timeliness of a process in the SPO

that could negatively impact each of these four aspects of the program.

Specific Requirement. One such process is the Engineering Change

Proposal (ECP) process. ECPs are generated by the contractor, approved

by the government, and executed by the contractor; they are documenta-

tion packages which include the necessary details for making changes to

the contractual technical baseline (7:2). The steps involved in ECP

generation, review, approval, and implementation comprise the ECP

process (6:3). If the ECP process is not functioning in a timely

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manner, then untimely ECP processing may result in higher costs to the government. These costs include not only personnel resources lost due to inefficient and untimely ECP processing, but also higher prices for implementing changes in hardware later as opposed to sooner. Also, proposed solutions to performance or logistics supportability problems or enhancements that require the technical baseline to be changed might have to be implemented later than desired because of untimely ECP processing. This delay could negatively impact the scheduled delivery of performance or supportability improvements that are needed to meet a certain level of capability. Thus a specific requirement exists to have an ECP process that is both efficient and timely.

The Problem Statement and Motivation of the Study

A Perceived Problem. However, based mainly on the results of informal and undocumented internal time studies, the ACM SPO director, project managers, and functional managers have questioned the timeliness of the ECP process (16). Furthermore, the process has recently been identified by the ACM managers as an "ACM critical process," one that is critical to program success (16). The managers have formed a critical process improvement team (CPIT) to study the overall ECP process in the ACM SPO and to make recommendations regarding the process' efficiency and timeliness (16).

Problem Statement. Based on the perception that the process is potentially untimely, the specific problem this thesis will study is the timeliness. or lack thereof, of the ACM SPO ECP process.

Motivation of the Hypotheses. Indeed, if the ECP process is untimely, then the process needs to be improved so that the United

States does not have to wait any longer than necessary to field this deterrent weapon and so that the additional costs associated with untimely and inefficient processes will be saved. Furthermore, specific requirements must be met if a process like the ACM SPO ECP process is to be timely. For example, a process involving many people requires not only sufficient numbers of people available to handle their workloads, but also people who are willing and able to communicate with one another. Furthermore, since an ECP is a document, the preparer of the ECP must be able to effectively describe the need in words, and the government personnel must make every effort to assist in the preparation process. These specific requirements may be lacking in the ACM SPO, and they lead to the set of hypotheses that the researcher has developed and discusses below.

Tentative Hypotheses

In order to determine whether or not the ECP process in the ACM SPO is untimely, hypotheses will be made and tested using the methods outlined in Chapter III. The researcher has constructed two areas of hypotheses, and the presentation of these hypotheses will follow the general flow pictured in Figure 3. First, the perceived timeliness problem will be studied by analyzing a hypothesis about the timeliness of the ECP process. The second set of hypotheses will be based on the requirements for timely processing, stated above, and on the assumption that the data indicates a timeliness problem.

The First Hypothesis. The first hypothesis states simply that the ACM SPO ECP process is not timely. This hypothesis will be tested by comparing actual times to complete process steps to the amount of time
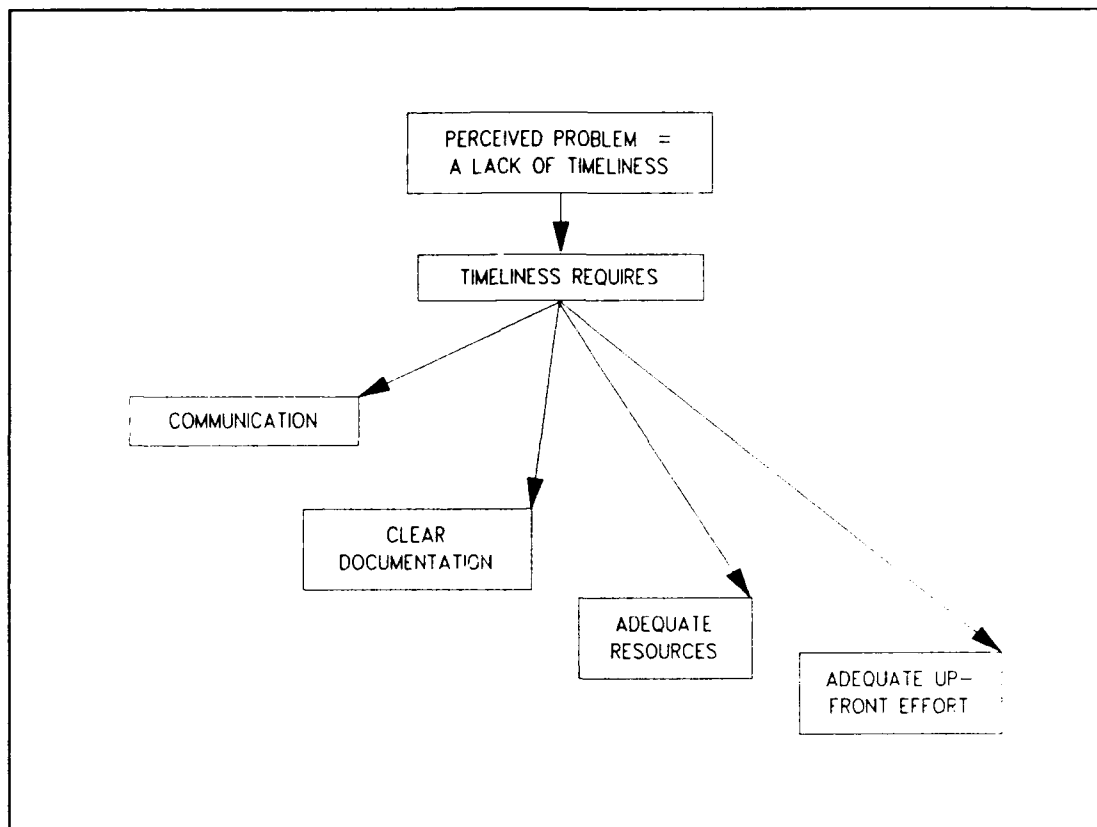
Figure 3. Flow of Presentation of Hypotheses

allowed in the ACM SPO Configuration Management Plan (CMP) which is a
contractual document between the ACM SPO and the contractor.

The Second Set of Hypotheses. For this second set of hypotheses,
we make the assumption that the ECP process has already been found to be
untimely. Then, if the ACM SPO is to improve the timeliness with which
it implements ECPs, it must identify the requirements for effective and
efficient ECP processing. Four hypotheses are proposed which are
potential barriers to timely ECP processing.

1. Communication. The ACM SPO consists of about 180
personnel in 13 different offices, or directorates. Approximately 80 of
these personnel are involved in the ECP process at any one time, each

involved with the processing of any number of ECPs from one to 30. Coordinating the efforts of the individuals involved in the process is a complex task, and it is one which justifies this first hypothesis: *ACM SPO personnel do not sufficiently communicate with other ACM program personnel within or outside the SPO.* Potential causes of the lack of communication are numerous--two examples follow: excessive numbers of temporary duty (TDY) assignments prevent ACM SPO personnel from being available to discuss issues, or workers simply fail to discuss their efforts with their supervisors. This lack of communication between subordinates and supervisors results in uncoordinated, delayed, or wasted efforts, especially when subordinates do not communicate with members of the SPO who are involved in the ECP approval process.

2. <u>ECP Submissions</u>. A second requirement exists if ECP processing is to be timely. Since the contractor is required to draft, edit, and submit ECPs to the ACM SPO, if the submittal is poorly written or conveys a message which is contrary to what is intended, then either time will be spent interpreting and rewriting the submittal or the discrepancy will go unnoticed. This requirement for clearly written ECPs is perhaps not being met, which leads to the second hypothesis: *The contractor's ECP submissions are unclear, lack sufficient detail, and are inaccurate.* Conflicts between what is stated in the ECP and what is actually desired or required increase the time needed to iron out the differences and delay ECP approval.

3. <u>Personnel Resources</u>. A third requirement of the ACM SPO is people. People are needed to process the paperwork associated with ECPs and to perform other functions as well. However, if the number of

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personnel or the level of training of those personnel are insufficient to adequately perform their assignments, then a third problem, inherent in the third hypothesis, will exist: *The ACM SPO lacks adequate person-nel resources to handle the number of ECPs in the ECP process at any one time.* Without adequate personnel resources, either the length of time required for review and implementation of the ECPs by the appropriate personnel increases or the time remains the same but the effectiveness of the operation diminishes.

    4. <u>Preparatory Work at TCMs</u>. Finally, although the number of personnel and the level of training may be sufficient, if the person-nel do not adequately review the Technical Change Package (TCP), a docu-ment from which the ECP is prepared, before the Technical Coordination Meeting (TCM), the meeting at which the TCP is reviewed with the contractor, then the ECP may have content and or documentation errors which could delay approval of the ECP. The fourth hypothesis is a statement about the TCP and TCM review effort: *Insufficient up-front effort by government personnel at Technical Coordination Meetings results in time delays.* Again, if the TCP is not reviewed by all of the functional specialists, or if the person reviewing the TCP does not attend the TCM, then the ECP could be submitted to the government with content or documentation errors which will need to be fixed before the ECP can be approved. This "fixing" process could take extra time, time which could result in delayed implementation of hardware enhancements.

Justification

    Why is the ACM SPO ECP process being studied? The answer lies in the importance of the ECP process to the United States. Recall, a major

overall goal of the United States is to maintain peace with the Soviet Union (26:1-5). To keep the peace, the United States is relying on a strong deterrent force consisting of ground-, sea-, and air-based weapons and delivery systems (26:4-5). However, the effectiveness of the air-based portion of the TRIAD has grown weaker as the Soviet Union has made advancements in its defensive capabilities (29:28). The United States has decided to improve the deterrent capability of this portion of the TRIAD through development and deployment of the ACM (31:156). The ACM SPO has been tasked to develop and deliver to SAC the ACM as rapidly as possible (10:1-4). To meet its goal of timely deliveries to SAC, the ACM SPO is required to have timely and efficient processes. However, the ECP process has been perceived to be untimely (16). Also, the ECP process is believed to be delaying the delivery of a level of deterrent capability to the user, decreasing ACM SPO productivity, and increasing costs (16). Furthermore, the defense industry can ill afford inefficient and costly operations in this age of defense budget cuts and manpower reductions. Through implementation of research findings, it is anticipated that the magnitude of all of these problems can be reduced.

Scope of Research and Limitations of Findings

Scope of Research. Although there are other internal SPO processes in the ACM SPO, this research effort will be limited to a study of the ECP process. Furthermore, although other problems may exist within the ACM SPO ECP process, this thesis will be limited to analyzing only the five hypotheses listed above. Moreover, a specific time period will be studied, including the period from June 1988 through August 1990; it is possible that different conclusions could be obtained by studying a

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different period of time. Finally, even though many different organizations are involved in the ACM SPO ECP process, this study will concentrate primarily on the interactions of the ACM SPO personnel in and among themselves. All of these limitations serve to narrow the scope of the problem so the specific problem can be studied in more detail.

Limitations of Findings. The proposed solutions to improving the timeliness of the ECP process will be based on the findings regarding the timeliness of the ECP process and on the results of the analysis of a survey conducted in the SPO in the Fall of 1989. The findings about the timeliness of the ECP process will be limited by the time period from which the data will be collected. Also, the findings from the survey analysis will be limited by the validity of the survey instrument. Rather than discuss the specific details of these limitations here, they will be discussed in conjunction with the presentation of the results in Chapter V. Finally, although the possibility exists that the findings presented here are applicable to other organizations suffering problems similar to those presented here, they may not be applicable. However, by performing the research steps presented herein, a set of problem solutions may be able to be obtained.

Definitions

The following words and acronyms are defined to facilitate the mutual understanding of the words in this thesis. These words are broken out by subject area and alphabetized within the subject area; for example, acronyms of organizations are grouped together, as are the group of words applicable to the ECP process.

Of Organizations. The following acronyms are for the

organizations which are involved in the ACM SPO ECP process.

GD/C -- General Dynamics/Convair, the prime contractor which is responsible for producing ACMs and is the design agent for the ACM

MDMSC -- McDonnell Douglas Missile Systems Company, the dual source contractor responsible to producing "build to print" ACMs using GD/C's approved engineering drawings

OCALC -- Oklahoma City Air Logistics Center, the future primary support organization for the ACM (10:11)

SAC -- Strategic Air Command, the United States Air Force command which oversees all United States strategic forces except for submarine launched ballistic missiles (25:2); also, the future user of the ACM (10:3)

SPO -- System Program Office, a military organization which is tasked with ensuring a weapon system is produced in accordance with the requirements

Of the ECP Process. The following words and acronyms are related

to the engineering change proposal process in the ACM SPO.

ACSN -- Advanced Change Study Notification, "a document prepared by [either] the contractor or the government which identifies the need for a technical change to the contract. The ACSN is used to initiate the preparation of a routine ECP" (7:1). ACSN approval authorizes the contractor to expend the resources necessary to prepare an ECP (5).

CCB -- Configuration Control Board, a group of individuals who review EtPs and make a recommendation, either approved, approved with comments, disapproved, or deferred, to the CCB chairman

CMP -- Configuration Management Plan, a document stipulating how the contractor and the ACM SPO are to process engineering and contract change proposals

ECP -- Engineering Change Proposal, a document used for approval authority of configuration changes

TCM -- Technical Coordination Meeting, a meeting between government and contractor personnel to informally review the TCP for technical and administrative accuracy before the formal ECP is submitted

TCP -- Technical Change Package, the complete, unsigned, change package which contains the details of the change, less cost information, and which will be corrected (if necessary) based on the comments of the government personnel at the TCM and submitted as an ECP

Of General Air Force Terms. The following words and acronyms are peculiar to the Air Force and include those terms related to the national security of the United States.

ACM -- Advanced Cruise Missile, air-launched air-to-ground strategic nuclear weapon systems which will become a part of the United States' air-based nuclear deterrent forces when operationally deployed (2:2-1)

Cruise Missile -- an unmanned, winged air vehicle with a nuclear warhead that is capable of guiding itself to a preselected ground target (31:156)

Deliver -- to provide; in this thesis, to ship a missile to the user so that it may be deployed

Deploy -- to operationally deploy a weapon is to put it in a condition such that it is ready to be used for its purpose

Deterrence -- A state of mind brought about by a threat of unacceptable counteraction (25:1)

Deterrent -- a weapon system is an effective deterrent to war if it is sufficiently powerful, in the eyes of the enemy, to influence or otherwise prevent the enemy from engaging in hostile actions

Survivability -- to endure by benefiting fully from early warning, quick reaction, dispersal, hardening, and mobility [and the use of radar-evading technology] (25:1)

Strategic -- [as in strategic bombardment] of or relating to the destruction of the enemy's war-making capacity represented by his industrial and technical strengths, most of which are located in urban industrial complexes (25:1)

TDY -- Temporary Duty, performance of work at a location other than the normal location for a period of time less than 180 days

TRIAD -- the land-launched ICBMs and manned bombers [with their payloads of cruise missiles and bombs] of SAC, combined with the Navy's ballistic missile submarine fleet form the TRIAD of strategic offensive forces (25:2)

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Summary of Chapter I

In this chapter, general introductory background material was provided to describe the global scenario as of the Spring of 1990, including the importance of the Advanced Cruise Missile to the continued strength of the nation's deterrent forces. The goal and requirements of the ACM SPO were presented, and the specific problem in the ACM SPO was discussed. One hypothesis stated the ECP process was untimely, and four more hypotheses were presented that were based on the first hypothesis being true. The specific research topic was justified, and the scope and limitations of the research findings were discussed. Finally, as a reading aid, important words and acronyms were defined and spelled out. Now that the general view has been presented, specific background material will be discussed in Chapter II, including the mission and organization outside and within the ACM SPO, a definition of the ECP and a description of the ECP process, and a historical perspective of the researcher's prior activities in the SPO, including the prior attempts at improving the ECP process within the ACM SPO.

II. Background

Chapter I presented specific hypotheses about the timeliness of the ECP process and the ability of the SPO to effectively perform the ECP process. To be able to better understand the hypotheses, this chapter describes the ACM SPO, including its mission and its organizational structure. The ACM SPO works with outside agencies, so these agencies will be presented as well. The ACM SPO and its relationship to other organizations will facilitate the discussion of the ECP and especially the ECP process. Next, the time requirements within which ECPs should be implemented are presented. Finally, the researcher worked in the ACM SPO from the Fall of 1986 to the Summer of 1989, so his role in the SPO will be presented along with the prior attempts of the SPO to correct ECP process problems.

ACM SPO, Mission and Structure

So that the reader may better understand the environment of the ACM SPO, the following discussion restates the ACM SPO's specific mission, explains how the ACM SPO is organized within the Air Force and within itself, and shows the approximate number of people in the SPO who are actually involved in the ECP process.

The ACM SPO Mission. The mission of the ACM SPO is similar to the mission of the typical SPO:

> The Program Office (PO) [also, System Program Office or SPO] is the "backbone" of the system acquisition process. Without it, the program will never be able to stand successfully. The PO is the management focal point ... for all agencies involved in the system acquisition as well as the only organization authorized to direct the system contractor's efforts. (19:1)

With this kind of responsibility, the general mission of the typical SPO is "to get a system to the user which meets cost, schedule, logistic supportability, and performance requirements levied by DOD" (19:3).

Given this general mission, the ACM SPO's specific mission is to deliver Advanced Cruise Missiles and the necessary support equipment to SAC, meeting the cost, schedule, logistic supportability, and performance requirements outlined in its Program Management Directive (10:1-8).

External Hierarchy. Before discussing the ACM SPO in detail, a brief synopsis of the chain of command from the United States Department of Defense (DOD) to the ACM SPO is in order. Figure 4 shows the external hierarchy from the Department of Defense to the ACM SPO. Within the DOD, the United States Air Force (USAF) is responsible for the acquisition, support, and operations of all USAF weapon systems. Examples of USAF weapon systems include tactical, airlift, strategic bombing, and reconnaissance aircraft and systems which are intended to support, respectively, Army ground troops, worldwide mobility, offensive and counteroffensive attacks, and surveillance (28:1-2 and 24:1-2). Another example includes air-launched strategic nuclear missiles which are used primarily for deterrence to war (31:156). Within the USAF, departments or commands are broken out primarily by the function they serve within the USAF. For example, the Strategic Air Command (SAC) is responsible for the operation of all strategic weapons systems, including the strategic bombing and reconnaissance aircraft and the strategic missiles (25:3). Air Force Systems Command (AFSC) is another USAF command; AFSC is responsible for overseeing the development and
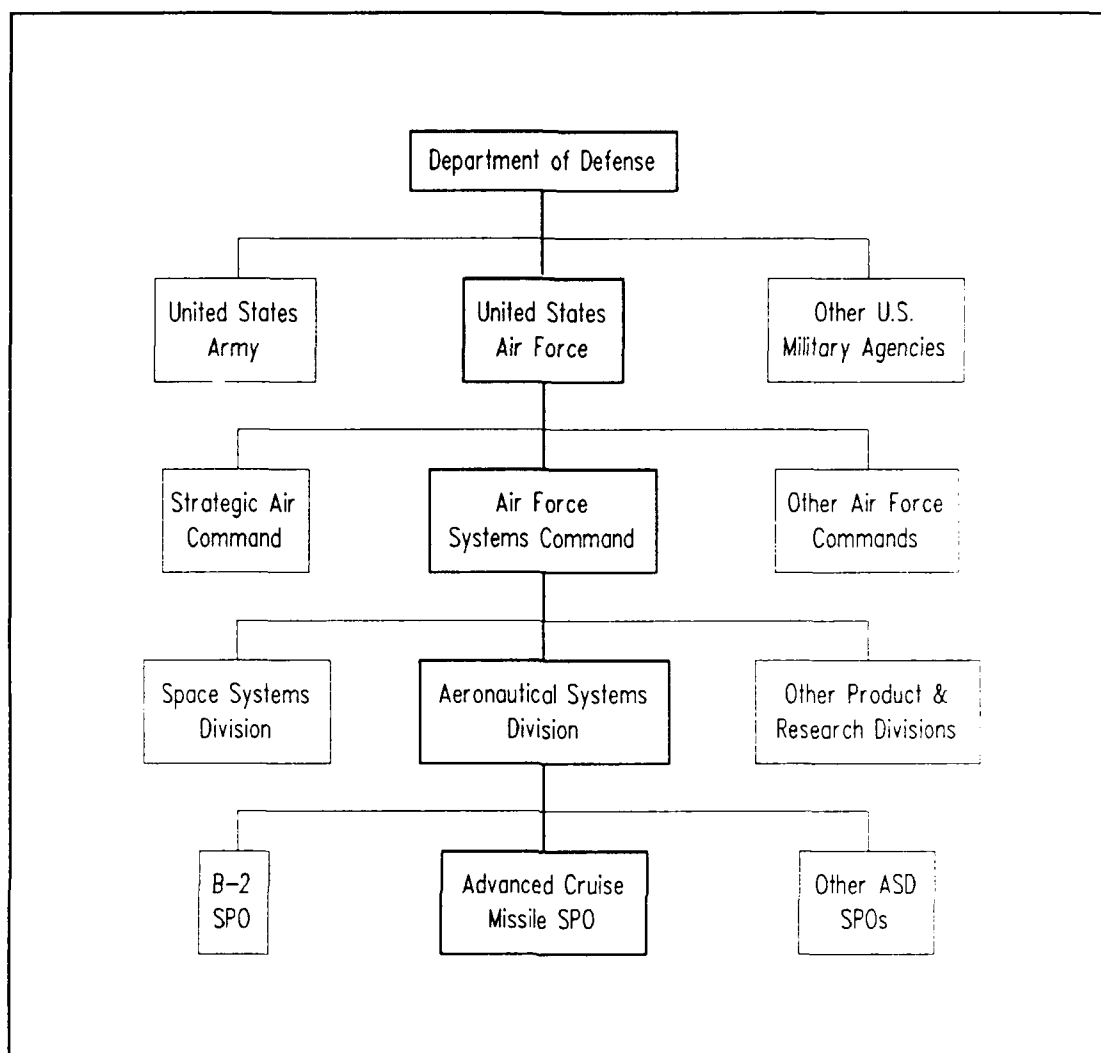
Figure 4.   Chain of Command from DoD to the ACM SPO

procurement of practically all USAF weapons, regardless of the command
which will ultimately use them (27:2).   AFSC is divided into divisions
which either concentrate primarily on products or on research.   The
Aeronautical Systems Division (ASD), located at Wright-Patterson AFB in
Ohio, is one of those product divisions.   ASD has SPOs which are
responsible for the design, development, production, and initial opera-
tional support of a specific weapon system or group of weapon systems.

Whereas the ACM, F-16, B-1, and B-2 SPOs are concerned with all aspects of one specific weapon system, the Training SPO is an example of a SPO which deals with a group of weapon systems. ASD SPOs usually have a two-letter designation that is used as an address. The ACM SPO's two-letter symbol is "VC," so that a reference to ASD/VC would indicate the ACM SPO within Aeronautical Systems Division. With approximately 140 government personnel and about 40 additional contractor personnel, the ACM SPO also has within itself a logically-arranged organizational structure; this internal structure is described next.

ACM SPO Internal Organization. The typical SPO is organized by the program director, who "purposely tailors the internal organizational configuration of the SPO to fit the needs and constraints of the particular program" (19:1). The ACM SPO is currently organized as shown in Figure 5, which indicates the structure and the number of authorized and actual personnel in each directorate as of June 8, 1990; these numbers have remained relatively constant through the period in which this thesis was performed (15). The program director is entitled to organize the SPO because "he must define the objectives and make the ultimate decisions which affect the cost, schedule, logistics supportability, and performance of the system" (19:1). The ACM SPO director has divided his organization into 13 directorates; each of these directorates performs specific roles or functions in the SPO, as outlined below (their office symbols are indicated in parentheses) (16).

Projects & Dual Source Directorates (VCA & VCB). The Projects Directorate consists of the project managers who are responsible for the acquisition and integration of specific parts of the

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┌─────────────────────────────────────────────────────────────────────────┐
│                                                                           │
│  ┌──────────────────────┐   ┌──────────────────────┐                     │
│  │ SEMCO, ARINC, & TASK │═══│ Program Director & Staff│  TOTAL: 186 / 178 │
│  │          40          │   │          7/7          │                     │
│  └──────────────────────┘   └──────────────────────┘                     │
│  ┌──────────────────────┐              ┌──────────────────────┐           │
│  │       Projects       │              │     Dual Source      │           │
│  │        17/13         │              │         5/6          │           │
│  └──────────────────────┘              └──────────────────────┘           │
│  ┌──────────────────────┐              ┌──────────────────────┐           │
│  │  Acquisition Planning │              │  Test and Evaluation │           │
│  │         2/2          │              │         7/5          │           │
│  └──────────────────────┘              └──────────────────────┘           │
│  ┌──────────────────────┐              ┌──────────────────────┐           │
│  │Configuration Management│             │ Management Operations │           │
│  │        11/8          │              │         5/5          │           │
│  └──────────────────────┘              └──────────────────────┘           │
│  ┌──────────────────────┐              ┌──────────────────────┐           │
│  │     Engineering      │              │      Contracts       │           │
│  │        27/27         │              │        16/16         │           │
│  └──────────────────────┘              └──────────────────────┘           │
│  ┌──────────────────────┐              ┌──────────────────────┐           │
│  │      Logistics       │              │   Program Control    │           │
│  │        20/20         │              │        10/10         │           │
│  └──────────────────────┘              └──────────────────────┘           │
│  ┌─────────────┐  ┌─────────────┐  ┌─────────────┐                        │
│  │   Security  │  │Manufacturing│  │    Safety   │                        │
│  │     3/3     │  │    15/15    │  │     1/1     │                        │
│  └─────────────┘  └─────────────┘  └─────────────┘                        │
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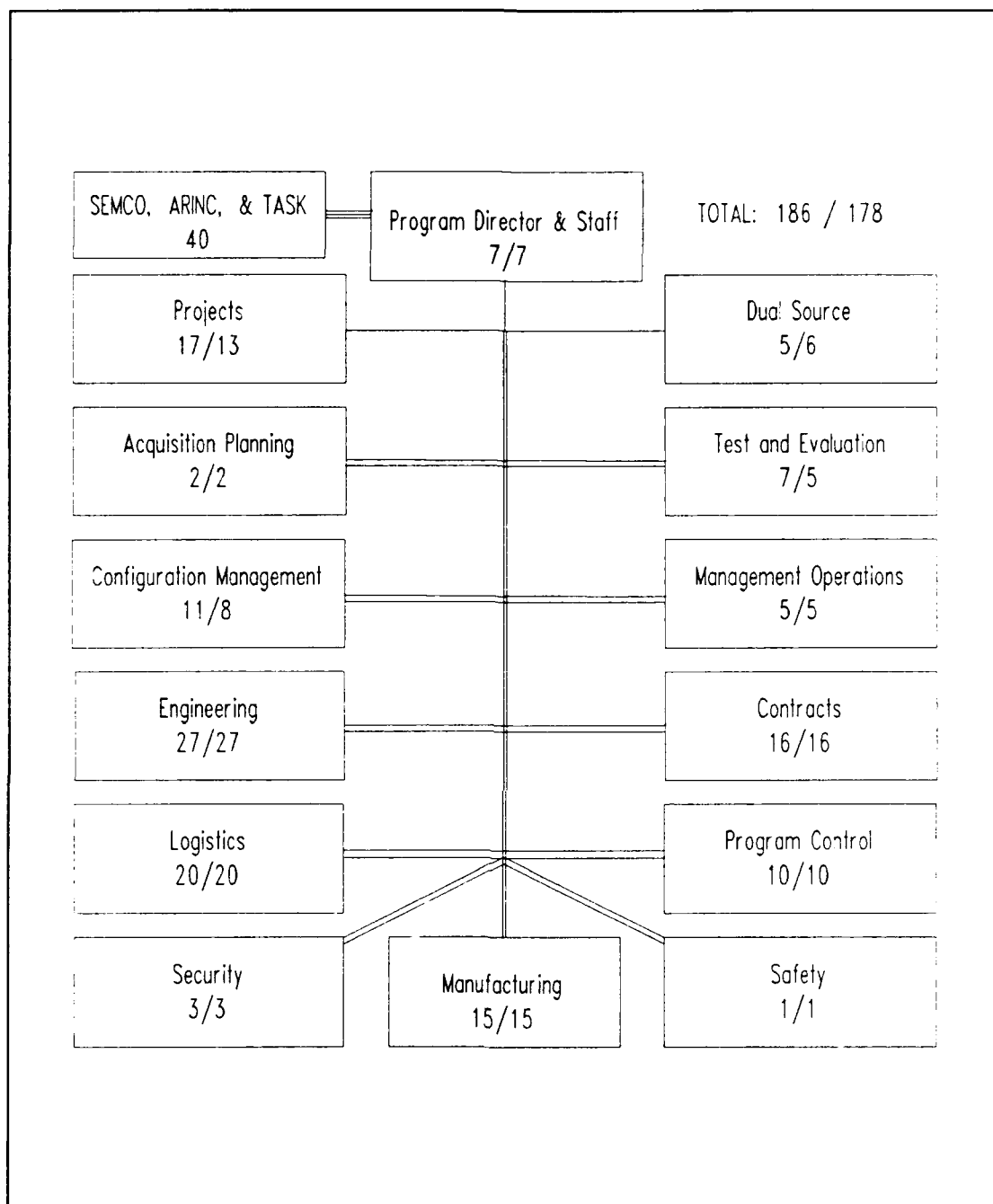
Figure 5. ACM SPO Internal Organization

Note: Functional Organizations Designated by Double Lines

missile into the whole (16). For example, the development, production,

and integration of the missile's engine, guidance system, software,

etc., must be managed so that the end result is a functioning cruise

missile (16). The Dual Source Directorate (VCB) is essentially

identical in purpose and function to VCA, except that VCB oversees the

activities of the dual source contractor, McDonnell Douglas Missile

Systems Company (MDMSC), while VCA oversees the General Dynamics/Convair

(GD/C) effort. These project managers help the program director fulfill

the SPO's mission, and they must get work done with the help of

personnel from the other directorates, including engineering, manufac-

turing, contracts, program control, and the rest shown in Figure 5 (16).

These other directorates are designated as "functional"

directorates because their primary mission usually consists of advising

and supporting the program director in their specific "functional"

specialties (19:10). Of these functional directorates, the most

important one to the processing of Engineering Change Proposals is the

Configuration Management Directorate (VCC). The purpose of the other

functional personnel, with respect to the ECP process, is usually to

review the ECP and provide comments regarding it relative to their

specific functional area (7:7). In light of this, VCC's role in the ACM

SPO is presented below, while the specific roles of the other functional

organizations are presented in Appendix A.

Configuration Management Directorate (VCC). Generally

speaking,

> Configuration management is charged with formalizing the system
> requirements into systems specifications, controlling the
> hardware/software configuration, and accounting for all configura-
> tion items. In addition to performing the data management
> function for the SPO, this [directorate] manages the system
> configuration control board [CCB] activities and all engineering
> change proposals [ECPs]. (19:12)

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Specifically, VCC is responsible for the following activities related to the ECP process in the ACM SPO:

- Receiving and evaluating all change proposals [and] ACSNs ... for compliance with [the requirements].

- Establishing and maintaining official files for all proposals.

- Establishing and maintaining a tracking system for all change proposals/ACSNs.

- Identifying the OPR for each change.

- Distributing proposals to all CCB members for review and comment.

- Preparing and distributing a periodic report identifying the current status of all open change proposals.

- Initiating a bi-monthly telecon with the contractor to establish/maintain change proposal schedules.

- Initiating and chairing TCM meetings

- Preparing and distributing CCB membership orders.

- Preparing and distributing the CCB agenda 3 working days before each CCB meeting.

- Serving as Secretariat to the CCB.

- Preparing CCB Directives (CCBDs) and obtaining required signatures.

- Preparing and distributing CCB minutes not later than 3 working days after CCB meeting.

- Ensuring all companion change proposals are sent to the appropriate proposal manager for processing with the original change proposal.

- Provide all unsolicited changes/revisions to previously dispositioned change proposals to the OPR for resolution. (7:4)

Many of the terms above have not yet been defined but instead are defined in conjunction with the description of the ECP process. Suffice it to say that the role VCC plays in the ECP process is crucial to its success in implementing design changes in a timely and efficient manner.

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ACM SPO Personnel Involved in the ECP Process. Within each of the directorates in Figure 5, a number of individuals get involved with processing an ECP. Table 1 shows the approximate number of people in each directorate who may be involved in the ECP process at any one time (17). As stated previously, the roles of the individuals in these

TABLE 1

NUMBER OF ACM SPO PERSONNEL INVOLVED IN THE ECP PROCESS (17)

Directorate	Number of Personnel
Projects	9
Dual Source	4
Configuration and Data Mgmt	8
Manufacturing	5
Engineering	17
Safety	1
Contracts	8
Logistics	5
Program Control	3
Security	3
SAC Liaison	1
Test	3
SEMCO, ARINC, and TASK	15
Total	82
Total in the ACM SPO	182

organizations with respect to the ECP process is primarily to review the ECPs with respect to their specific functional specialty (7:7).

Summary, ACM SPO Organization. Here we've seen the specific mission and organization structure of the ACM SPO. We looked at how the ACM SPO is organized with respect to the Department of Defense and how

the SPO has organized itself to accomplish its mission. Furthermore,
we've seen how many people in the SPO get involved in the ECP process.
However, more people are involved in the ACM SPO's ECP process than just
the ACM SPO personnel. This next section discusses the other players in
the ECP process.

Outside Organizations that Work with the ACM SPO

The following organizations work with ACM SPO personnel on at
least an occasional basis, based on whether or not the specific ECP in
question impacts their areas of responsibility. Figure 6 provides a
picture of the relationships that exist between these organizations.
The double lines represent direct contractual arrangements between
organizations, while the single line indicates the lines of
communication and coordination between organizations that do not have
contractual agreements.

General Dynamics/Convair. GD/C is one of the ACM SPO's prime
contractors, prime in the sense that it has signed a contractual
agreement with the SPO to deliver complete and functioning weapon sys-
tems (16). The prime contractor can choose to build what the government
wants by itself, or it can sub-contract out some or all of the pieces of
the effort to other organizations. GD/C has chosen to sub-contract out
parts of the effort, including the navigation, fin control actuators,
and other systems to others while retaining overall integration respon-
sibility for itself (16). GD/C was chosen in 1983 to develop the ACM,
which it has done (16). Although GD/C has produced and delivered some
ACMs to the Air Force, it is still involved in the modification of the
design to some extent, especially in the area of engineering design
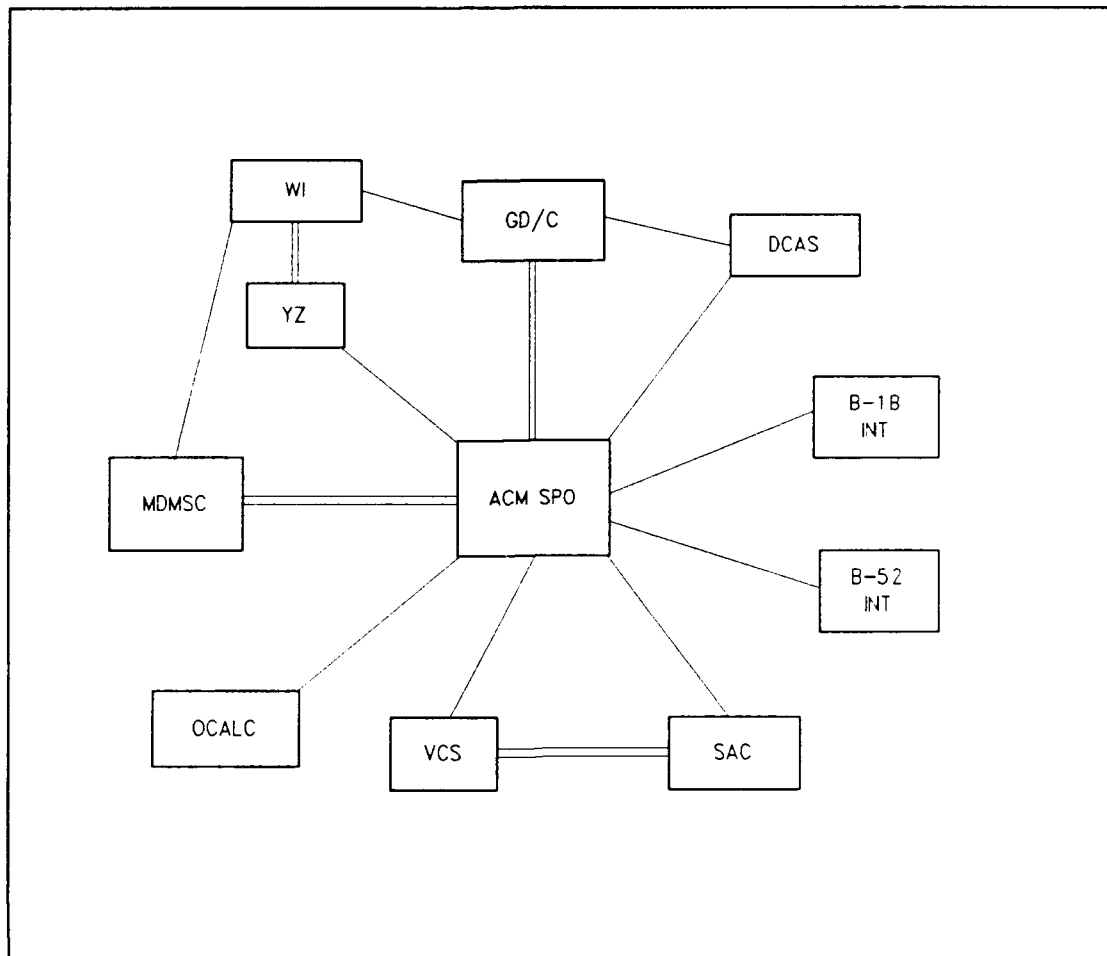
Figure 6.   Organizations that Interact With the ACM SPO

changes and modifications (16).   GD/C must interface directly with MDMSC

before it can propose an engineering design change because all design

changes that GD/C may wish to propose to the government must first be

analyzed by MDMSC before they can be proposed to the government (this is

true because of the dual source relationship of MDMSC to GD/C, described

below) (6:13).   Furthermore, GD/C interfaces with Williams International

(WI), the manufacturer of the engine, via an Interface Memorandum (IFM)

when GD/C experiences difficulty integrating the engine into the missile

(24).   GD/C is responsible for integrating the engine into the missile,

so IFMs are used as an informal mode of communication between the two even though a contractual relationship does not exist between them (24).

McDonnell Douglas Missile Systems Company. MDMSC is the second prime contractor building ACMs. MDMSC is what is known as a "dual source" contractor which means that it is responsible to the government for producing "build to print" hardware; MDMSC will use the same blue prints that GD/C uses and produce hardware that is indistinguishable from the hardware built by GD/C (18). MDMSC's contract is with the ACM SPO (18). Furthermore, MDMSC must work with GD/C on ECPs for the same reason that GD/C must work with MDMSC: the dual source relationship means that any design changes that either GD/C or MDMSC wishes to propose must be analyzed by the other contractor before they can be proposed to the government (6:13). Because of this requirement, both contractors share in the same knowledge throughout the dual source arrangement. MDMSC was chosen, in a competitive source selection, to fulfil the role as the second producer of ACMs in November, 1987 (18). It is important for MDMSC to be in the ECP process loop not only because of the DOD-STD-480A requirement but also because any approved design changes that GD/C implements in its hardware or software, depending on the specific change, may also be required to be implemented in the hardware or software of the missiles that MDMSC builds (18). Furthermore, MDMSC was chosen to not only produce ACMs "build to print," but also to propose design changes when it can show that cost savings, maintainability enhancements, or other benefits to the government can possibly be achieved (18). However, potential design changes that could be beneficial to the government may not be proposed by these contractors

because of the adversarial relationship that potentially exists between them (18). This adversarial relationship could exist based on the following facts:

1. General Dynamics spent more money designing, developing, and testing the ACM than it received from the government; this money can only be recouped by obtaining future production contracts and efficiently delivering systems to those contracts (18).

2. GD/C, before the dual source source selection was initiated, was hoping to have a chance to recoup some of its losses on future production contracts (18). However, the dual source is expected to compete for a lion's share, perhaps up to 70%, of future production efforts, so GD/C's chances of recouping lost dollars is diminished (18).

3. After MDMSC was chosen, GD/C was left with the realization that not only was MDMSC the new competitor for future ACM production contracts, but also that this was the third weapon system that GD/C had designed but then been second sourced by MDMSC--the first two systems were the Tomahawk Cruise Missile and the Ground-Launched Cruise Missile (GLCM) (18). Furthermore, for the Tomahawk and GLCM programs, MDMSC was the contractor that built the guidance system for GD/C, and GD/C integrated the guidance unit into the structure of the missiles (18). So, when MDMSC became the second source to GD/C, MDMSC gained GD/C's experience and technology for building the structure of cruise missiles and GD/C gained MDMSC's experience and technology for building guidance systems (18). However, since MDMSC had not been involved in building any of the ACM's subsystems, MDMSC had nothing to offer GD/C with respect to the ACM, except to take future dollars away from General Dynamics (18).

Because of these events, neither GD/C nor MDMSC is totally committed to sharing knowledge gained through their particular experiences, and, as a result, engineering change proposals that could save the government money or make the maintainers' lives easier may be delayed or withheld by one contractor because of the potential benefits the other contractor could reap as a result of the idea (18).

The Engine SPO (YZ). The Engine SPO has personnel in it who are the procuring agents for the engine that is installed in the ACM (24). The YZ SPO is a system program office in Aeronautical Systems Division, and the contract for producing the ACM engines is between YZ and WI (24). Whenever an IFM is sent between GD/C and WI, both YZ and the ACM SPO receive information copies of the message (24). The engine project officer in the ACM SPO then works with YZ and GD/C personnel to resolve any problems or issues (24).

Defense Contract Administration Service. DCAS is a government organization which provides the ACM SPO with administrative and technical support (16). They work alongside GD/C personnel, and have their office in the same building in which the ACM is assembled. DCAS provides valuable experience to the ACM SPO, especially in the area of how GD/C operates (16). With respect to the ECP process, they review and comment on all ECPs.

Oklahoma City Air Logistics Center. OCALC is the organization which will become the primary supporter of the ACM after a milestone event called Program Management Responsibility Transfer (PMRT) (10:11). While the ACM design is still undergoing modifications, the ACM SPO is responsible for supporting the fielded weapon systems (10:4). However,

after the design is stabilized, PMRT will take place, with OCALC's concurrence, and OCALC will become responsible for all support aspects of the program (10:11-12). Thus OCALC must be involved in the ECP process so that it will know not only the configuration of the missiles that it is becoming responsible for, but also how to support and maintain them.

Strategic Air Command. SAC is the ultimate user of the Advanced Cruise Missile (10:3). As the user, SAC will perform maintenance on the missiles, so it is very important for SAC maintenance personnel to be able to determine each missile's configuration (10:3). SAC is involved in the ECP process through their in-the-SPO resource, VCS (16). This office is manned by a Strategic Air Command mid-level liaison officer who is invited to review all ECPs and attend all CCBs (16). This officer provides the SPO the user's perspective, and vice versa.

SAC Liaison Office (VCS). VCS is not shown on Figure 5, even though its office is in the ACM SPO, because the office is manned by a SAC resource (16). Thus this officer reports only to SAC, not the SPO, allowing the using command (SAC) to have a direct advocate in the SPO (16). As SAC spokesmen, VCS personnel

> monitor and support system activities involving the system design,
> development, test, production, performance, reliability, main-
> tainability, training, and deployment. They advise the PM of the
> operating command's interests and concerns related to the opera-
> tional use of the system. (19:13)

B-52 Integration and B-1B Integration. These two offices also are manned by personnel from other Aeronautical Systems Division personnel who oversee the integration effort between the ACM and their respective carrier aircraft.

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Other Organizations. Other organizations occasionally get involved with ACM SPO ECPs, but mainly for support and other peripheral equipment (5). These organizations will not be addressed here, in the interests of time and space. We've now seen all of the personnel and organizations which get involved with the ECP process; it is now time to see just exactly what the ECP is and how one gets processed in the ACM SPO.

Engineering Change Proposal: Purpose and Process

Now that all of the players in the ECP process have been introduced, the ECP process and the personnel who perform the specific steps in the process can be described. This section will define and describe the engineering change proposal's purpose and its general process flow. Furthermore, the specific ECP process flow in the ACM SPO will be addressed, since its flow varies from the flow described in the regulations. This discussion will lend itself to the discussion in the next section, which will include a discussion of the time requirements within which the ACM SPO ECP process is to be performed.

ECP Purpose. An ECP is a document designed to maintain configuration control over hardware and software being produced for the government (6:iii). Department of Defense Military Standard 480A (DOD-STD-480A), Military Standard for Configuration Control Engineering Changes, Deviations, and Waivers, stipulates that proposed configuration changes will be identified via an engineering change proposal (6:1). DOD-STD-480A provides the information needed to ensure contractors maintain configuration control over the hardware and software they produce for the government (6:1). Specifically, ACM VC Operating Instruction 800-1

(VC OI 800-1), ACM Configuration Contract Change Control, echoes the

requirements for ECPs as stipulated in DOD-STD-480A:

> Each proposed change in configuration will identify the necessary
> corresponding changes and/or additions in related support equip-
> ment, tooling, spares, training equipment, technical publications,
> associate and/or dual source contractors. and any other areas
> needed to ensure total weapon system compatibility. When a
> proposed change requires additional tests, the scope of the test
> shall be defined....

> Each proposed change shall identify the total impact to the
> program, if approved, including the effect of the change on
> development, production, and retrofit to the system or equipment.
> Proposed change impacts on the dual source contractor shall be
> included in the decision process. (7:3)

Configuration control is critical to the government because without it

the systems will not be able to be maintained effectively once they are

deployed (17). The military standard stipulates that, "unless otherwise

specified by the procuring activity [in this case the ACM SPO], receipt

of contractual approval shall constitute the sole authority for the

contractor to effect the change" (6:15). In summary, engineering change

proposals have a specific purpose, to maintain configuration control,

and they must be used for approval of configuration changes (6:15).

Without the government's contractual approval, the contractor is not

authorized to perform the work necessary to implement a change, so

delays in ECP approval can result and have resulted in direct delays to

scheduled missile deliveries (17).

ECP Process, by Regulation. With the definition and purpose of

the ECP still in mind, what are the necessary steps to obtain approval

to implement a configuration change? DOD-STD-480A states the general

steps as follows:

> 4.1 General. The steps in processing an engineering change con-
> sist of the following: (a) determination of a need for the

change, (b) establishment by the originator of a classification of the engineering change as Class I or Class II, (c) preparation of an ECP, (d) submittal to the Government, (e) review, (f) approval/disapproval or concurrence/nonconcurrence in classification, and (g) incorporation of approved (or concurred in) engineering changes in the configuration item and in the data, including when applicable, negotiation into the contract. (6:3)

Although DOD-STD-480A lists the general steps involved in the ECP process, the ACM SPO has additional steps over and above those listed above. Indeed, the ACM SPO has not only added two steps into the process, but also often recycles ECPs through steps c, d, e, and f more than once because of problems with the words or content of the ECP packages. These problems require the contractor to make changes to the document and resubmit it to the government (17). Because of these extra steps, the ACM SPO process as it exists in practice will now be discussed.

The ACM SPO ECP Process, in Practice. Figure 7 shows the overall flow of the ECP process in the ACM SPO. The boxes with double lines around them indicate those steps which are not included in the regulation but instead have been added to the process either in an attempt to improve the overall timeliness of the process or because the process is not functioning ideally. The discussion below will follow the path of the ECP from the determination of a need for a change to the supplemental agreement (S/A) step, describing each step along the way.

Determine a Need for a Change. The first step in processing an engineering change is to determine a need for a change (6:3). Any organization, government or contractor, can initiate the change process by identifying a deficiency between how the system works and how it is supposed to, or should, work. The contractor, for example, could initiate the change process by discovering, through testing, a recurrent
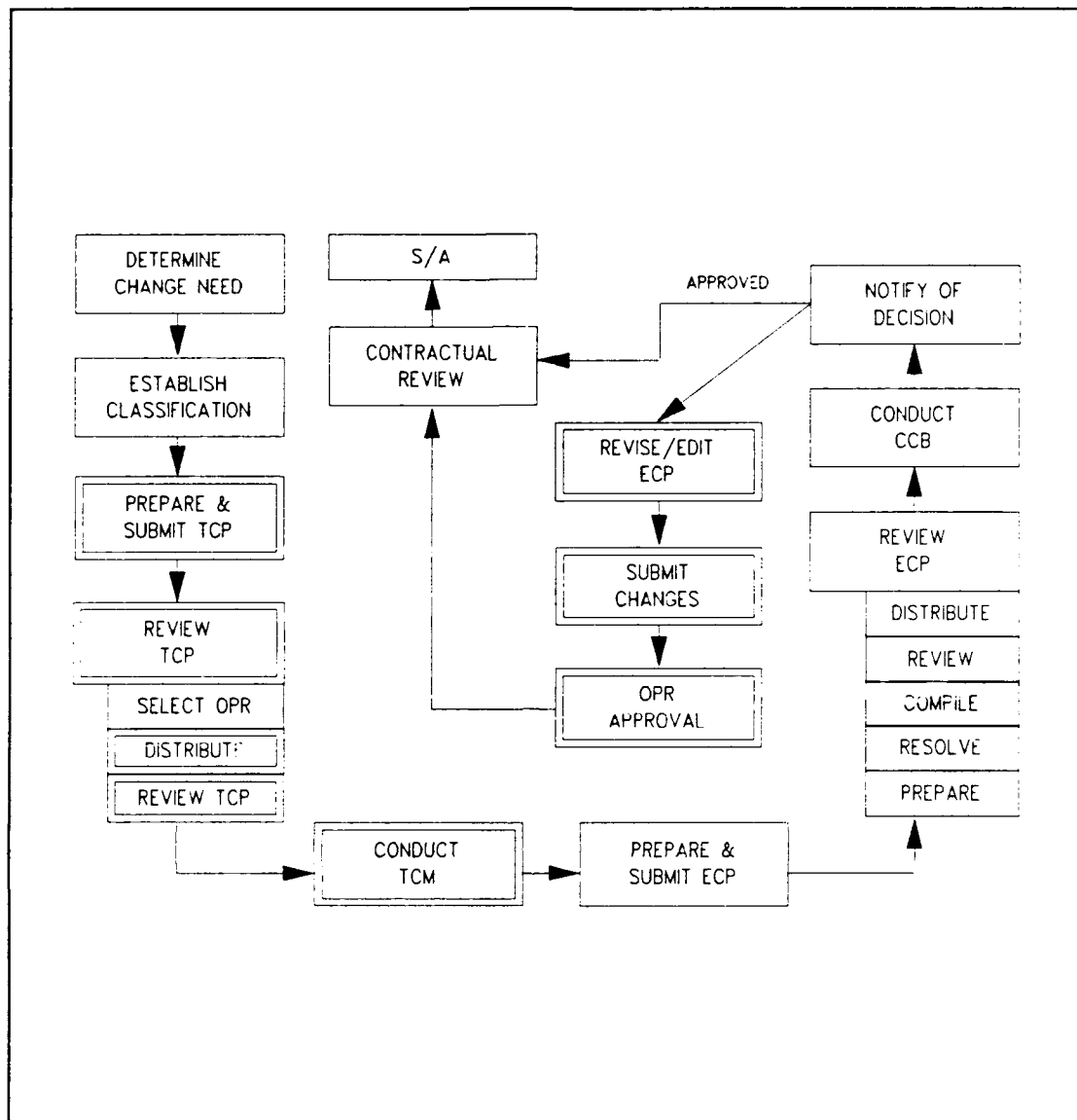
Figure 7. ECP Flow in the ACM SPO

problem that has no apparent or immediate solution. If it would be more

cost effective for the contractor to identify and fix the recurring

problem, rather than throw away the non-functioning hardware, it would

probably initiate a study to find the source of the problem. Such a

study may reveal a problem in a hardware design. To solve the problem,

the contractor may decide to change the design. If the problem results

in a deficiency to the contract, then the contractor might prepare an ECP and submit it to the government. However, if the solution to the problem is beyond the scope of the current contract, then the contractor may submit an Advanced Change Study Notice (ACSN), a standard government form used for these types of requests, to the government (17). The ACSN will identify the general concept of the change, the potential benefits of the change, and the rough order of magnitude cost of the change (17). The ACSN allows the contractor to propose the idea and, if the government likes it, the contractor may be asked to expend the resources to prepare the ECP that includes not only the technical details of the change but also the proposed costs of implementing the change (17). An ACSN can also be initiated by the government; the ACSN could direct the contractor to prepare an ECP based on the information in the ACSN. Of course, this ACSN would also have to authorize the contractor to spend the resources necessary to prepare the change (17). Based on the contractor's response as documented in the ECP, the government may decide to disapprove the change, but would still be required to pay the contractor for the costs incurred in preparing the ECP (17). These are just examples of how a design change gets initiated--regardless of how one is initiated, however, the remaining steps leading to actual implementation of the design change follow the same general flow (17).

<u>Establish the Classification</u>. Once a need for a design change is identified, it must be classified as either a Class I or a Class II change (6:3). Basically, the classification can be made by following the guidelines listed below:

4.2.1 <u>Class I engineering change</u>. An engineering change shall be classified Class I when one or more of the factors listed (sub-paragraphs a, b, c, d, or e) below is affected:

a. the functional or allocated configuration identification...

b. The product configuration identification (PCI) as contractually specified (or as applied to government activities), excluding referenced drawings, specifications, listings of computer program instructions, and actual data values

Note: In the above definition of a Class I engineering change, the words "excluding referenced drawings, specifications, listing of computer program instructions, and actual data values" in 4.2.1b shall not be interpreted to exclude these items prescribed directly in a contract to define contract line items. Other drawings, specifications, computer program instructions, and actual data values, whether referenced in documents or listed on associated lists, are excluded from 4.2.1b but included in 4.2.1c, d, and e.

c. Technical requirements below contained in the PCI as contractually specified, including referenced drawings and specifications

    (1) Performance outside stated tolerance
    (2) Reliability, maintainability, or survivability outside stated tolerance
    (3) Weight, balance, moment of inertia
    (4) Interface characteristics

d. Non-technical contractual provisions

    (1) Fee
    (2) Incentives
    (3) Cost to the Government
    (4) Schedules
    (5) Guarantees or deliveries

e. Other factors

    (1) Government furnished equipment (GFE)
    (2) Safety
    (3) Electromagnetic characteristics
    (4) Operational, test, or maintenance computer programs
    (5) Compatibility with support equipment, trainers, or training devices/equipment
    (6) Configuration to the extent that retrofit action would be taken
    (7) Delivered operation and maintenance manuals for which adequate change/revision funding is not on existing contracts

(8)   Pre-set adjustments or schedules affecting operating limits or performance to such extent as to require assignment of a new identification number

(9)   Interchangeability, substitutability, or replaceability, as applied to CIs, and to all subassemblies and parts of reparable CIs, excluding the pieces and parts of non-reparable subassemblies

(10)   Sources of CIs or reparable items at any level defined by source control drawings

(11)   Skills, manning, training, biomedical factors, or human engineering design (6:3-5)

The above factors, for ease of discussion, will be referred to simply as "form, fit, and function" factors throughout the remainder of this document. So, if the form, fit, or function will be affected, then the change is considered a Class I change. Conversely, if form, fit, or function is not affected, then the change is considered a Class II change (6:5). DOD-STD-480A stipulates that the originator of the change determines its classification; however, the military standard also indicates that the government has the final approval authority with respect to the classification (6:3).

Why the Distinction Between the Classes? The distinction between the classes is made to identify the scope of the change and for administrative purposes--ACM Class I changes must be approved by the government using the ACM SPO ECP process, while Class II changes only require government concurrence that the change is indeed a Class II change (17). In fact, the ACM SPO has delegated the Class II concurrence authority to DCAS (17). Thus, when the contractor submits a Class II engineering change proposal to DCAS for concurrence, DCAS verifies the form, fit, and function are not affected before it concurs with the classification (17). DCAS can disagree, and has disagreed, with the contractor's submittal as a Class II change. When DCAS does

this, it refers the change to the ACM SPO which then can either concur with the classification as submitted or require the contractor to submit the proposal as a Class I change through the SPO ECP process (17). Furthermore, GD/C and MDMSC must agree upon the classification, otherwise the change will be referred to the SPO (17). DCAS will know about the lack of consensus on classification of the ECP because, before an ECP can be submitted to the government, the originator of the change must coordinate the proposal with the other prime contractor and indicate on the ECP the results of the coordination effort (6:13). The distinction between the classes is also made to ensure the proper program concerns are addressed, including, for example, whether or not logistics will be impacted because of the design change (17). For example, a change to a card inside an electronic box may not change the physical form of the electronic box, its fit within the missile, or its function; however, if the change results in a different part that must be spared or otherwise accounted for, then the change will need to be classified as a Class I change (17). For those changes identified as Class I, the next step in the ECP SPO process is to prepare and submit a TCP to the government.

Prepare and Submit the TCP. Now, after a need for a change is identified and classified, DOD-STD-480A states that the engineering change proposal will be prepared for submittal to the government (6:3). This will be done for Class II engineering changes, which will then be submitted to DCAS for concurrence on the classification (17). However, for Class I changes, the ACM SPO requires a Technical Change Package (TCP) be reviewed by the SPO before the ECP is prepared (14). Indeed,

A TCM between the Air Force and the contractor(s) will be held
during the preparation cycle of all formal ECPs, and as required
for CCPs. Likewise, a TCM will be held during the preparation
cycle of the formal proposal in response to a SPO approved
urgent/emergency change proposal. The TCM will be held after the
contractor has completed and made available the descriptive
portion of the change proposal as contained in the TCP and before
the contractor's pricing of that proposal.... To be specific, the
only exceptions to the TCP/TCM requirement are non-formal urgent,
emergency, and administrative change proposals and special cases
approved by the program manager and the Director of Configuration
Management. (7:7)

The government will review the TCP and provide comments about it to the

contractor at the Technical Coordination Meeting (TCM); these comments

will assist the contractor in its preparation of the ECP (7:7). The TCP

includes the technical details of the change; however, it does not

include any specific or firm cost data because

The function of the TCM is to establish the baseline as defined by
the documentation wording [TCP] to ensure accuracy and adequacy
before the contractor expends effort in pricing the proposal for
formal submittal to the SPO. (7:7)

Furthermore, the TCP should be prepared in accordance with the

requirements outlined in DOD-STD-480A for preparing ECPs because the

TCP, if approved as written, will be submitted to the government as the

technical portion of the ECP--the only differences being the cover

letter and the addition of a cost volume (5). After the TCP is

prepared, the contractor mails copies of the document to the ACM SPO,

OCALC, DCAS, and MDMSC (17). Once the TCP is received at the SPO, three

steps take place which lead up to the TCM. These three steps are

Selecting the Office of Primary Responsibility (OPR), Distributing

Copies, and Reviewing the TCP.

Select the OPR. When the ACM SPO receives the ECP,

the organization that actually receives and opens the document (or box,

for voluminous copies of ECPs) is VCC (17). VCC then determines the appropriate directorate within which the ECP should be assigned (17). The directorate is determined by a simple test: Is the ECP so specific that it is a concern strictly for only one directorate (7:Atch 1)? If the answer is yes, then the OPR will be chosen from within that directorate (7:Atch 1). If the answer is no, then the OPR will be chosen from within the Projects Directorate, VCA (7:Atch 1). VCC will not choose the specific individual within that directorate, but instead ask the directorate to make the selection (7:Atch 1). Usually, roughly 9 times out of 10, the OPR is chosen from VCA (17).

Distribute Copies of ECP within the SPO. Once VCC knows who the OPR is, they attach a cover letter to the front of the ECP and distribute a copy to each directorate in the SPO (17). The cover letter indicates the OPR, the date by which the TCP must be reviewed, and the projected date of the TCM (17). When the other directorates receive their copy of the TCP, a reviewer is selected to comment on the TCP with respect to his functional expertise (17). In some instances, proposals are complex enough to demand two or more personnel from the same directorate to review the document; this is especially true for VCE, for example, where one ECP may require review by multiple engineering disciplines (17).

Review TCP. Within the time allotted to them, these "chosen" reviewers should study the proposed change and, if necessary, take note of any issues that cross their mind as they complete the review. A frequent question many have asked is, for what should the reviewer look? The answer is, simply enough, anything that looks out of

the ordinary or that causes one to wonder about the answers to who,

what, when, why, or how, especially within the area of one's functional

expertise. Indeed,

> Although the contractor has the responsibility to define all
> impacts of a proposed change, each SPO Directorate shall ensure
> that all impacts to their specific areas of responsibility have
> been identified and adequately defined. (7:3)

After the review is completed, the reviewer should attempt to resolve

any issues that still remain by preparing to ask the contractor

questions at the TCM (17).

Conduct TCM. The purpose of the TCM is "to facilitate CCB

action, speed the processing of the change, and provide understanding of

change requirements between the contractor and the government" before

the ECP is formally submitted (7:2). The TCM is described below:

> TCMs will normally be conducted by teleconference with the
> appropriate SPO Change Manger, OPR, Program Manager, other SPO
> functionals as required and contractor representatives. If the
> complexity of the change proposal warrants, the TCM may be
> organized and conducted at a contractor facility or at the SPO
> with all representatives being present. The actual TCM date shall
> appear on a TCM schedule distributed by VCC and shall be a func-
> tion of the availability of required people. The TCP must be
> available to the SPO 7 to 10 days in advance of the actual TCM
> date. The OPR shall also ascertain if significant changes are
> anticipated from the Rough Order of Magnitude (ROM) price [a
> preliminary estimate of the possible cost of implementing the
> proposed design change] provided by the contractor on the ACSN.

> The TCM is an informal meeting and results in informal assurance
> to the contractor that the descriptive portion of a change propo-
> sal as presented in the TCP is accurate and adequately defines the
> change identified by the ACSN. Concurrence with the descriptive
> portion of the proposal by those in attendance at the TCM should
> reflect the opinion of the SPO community at large as attested by
> signature of the OPR and Change Manager on the TCM minutes. These
> signatures shall be acquired by the Change Manager within five
> days of receipt of minutes from the contractor. A copy of the
> signed TCM minutes shall be provided to the contractor by VCC
> immediately upon completion of all required actions. Once a
> change proposal has successfully passed the TCM milestone, the
> contractor should have received all necessary technical direction

required to complete preparation of the change proposal. Never-
theless, approval of the proposal cannot be assured until the CCB
has the opportunity to review the formal submission of the
proposal. (7:7-8)

So, if the TCP is adequately reviewed, then the TCM should provide the

contractor the information it needs to complete the ECP, including the

cost volume (7:8). However, if the TCP is not adequately reviewed, not

only might there be problems with the technical portion of the change,

but also with the cost portion of those changes that increase the scope

of the contract. Thus the TCM review process is perhaps the most impor-

tant activity for the SPO, MDMSC, DCAS, and OCALC personnel to perform

in a satisfactory manner because if a TCP is poorly reviewed, then the

quality of the ECP could be diminished. For example, if a technical

issue is overlooked, then the validity of the cost volume could be

impacted. Furthermore, either important considerations will remain

unnoticed or the issue that could have been identified, worked, and

corrected before the ECP is prepared may become an issue during the ECP

review process that could delay the presentation of the ECP at the CCB

(17). In either case, the consequences of an inadequate review are

severe, resulting in either poor decisions on the part of the government

or lost time while issues are worked out in the final stages of the

process rather than in the beginning. As stated above, the contractor

and the SPO perform steps to document the results of the meeting. These

steps include the preparation of the TCM Minutes by the contractor,

submittal of the minutes to the SPO, and Approval of the Minutes by the

SPO (7:8). If the SPO does not approve the minutes, then the SPO might

request the contractor to update the TCP for purposes of conducting a

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second TCM (17). In either case, the contractor may prepare the ECP an

submit it to the government after the TCM minutes are approved (17).

Prepare the ECP. Immediately after a need for a change is

identified and classified, the contractor may submit an ECP directly to

the government without the benefit of the TCP/TCM process if the

proposal is a "non-formal, urgent, emergency [or] administrative change

proposal [or if it is a] special case approved by the program manager

and the Director of Configuration Management" (7:7). In these

instances, the contractor is still responsible for preparing the ECP in

accordance with the requirements stipulated in DOD-STD-480A (6:12).

Furthermore, even though a TCM may have been conducted and no comments

were provided, the contractor still must submit an ECP to the SPO so

that the proposal may be formally approved at the CCB (7:8).

Submit ECP to the Government. Once again, if GD/C wants to

implement a Class II change, the ECP needs to be submitted to DCAS for

concurrence that the change is indeed a Class II change (17). If DCAS

concurs that it is a Class II change, then no other action on the part

of the ACM SPO is necessary (17). However, if the proposal is for a

Class I change, then the contractor must make sure the ECP gets to the

ACM SPO for the review and approval process because the ACM SPO is the

only government organization with approval authority of ACM Class I ECPs

(17). Furthermore, the contractor submits copies of the ECP to MDMSC,

OCALC, and DCAS who provide comments to the SPO to help it make its

decision to approve the proposal (17). Since the SAC liaison officer is

on the internal ACM SPO mailing list, all affected organizations receive

copies of and can begin reviewing each ECP at about the same time (17).

Review. Now that all the organizations have received a copy of the ECP, they can begin the review process. This review process includes the task of ensuring that the proper personnel in each organization are provided a copy of the proposal. Suffice it to say that DCAS, OCALC, and MDMSC have internal controls to ensure the proper personnel receive a copy of the ECP. These internal controls and review processes will not be discussed here because, since it is at the SPO that the decision will be made whether or not to approve the ECP, this thesis will concern itself with only the review process as it exists within the ACM SPO. Besides, part of the ACM SPO review process includes obtaining comments from these other organizations; hence, if any of the review processes at these other organizations is untimely, then that fact would become evident through the study of the ACM SPO's process and steps could then be taken to research the other organizations' internal review processes. So, confining our research efforts for now within the ACM SPO, the review process consists of disseminating copies of the ECP to each of the directorates, reviewing the document, compiling the comments, resolving the issues, and preparing for presentation to the CCB. These five steps are outlined below.

Distribute Copies of ECPs within the SPO. Since VCC already knows who the OPR is, they ask him when, within the next two to three weeks, he will be available to present the ECP to the CCB (17). Once the CCB date is determined, VCC attaches a cover letter to the front of the ECP and distributes a copy to each directorate in the SPO (17). The cover letter indicates the OPR, the date by which the ECP review comments must be returned to the OFR, and the projected date of

the CCB (17). When the other directorates receive their copy of the ECP, a reviewer is selected to comment on the ECP with respect to his functional expertise (17).

Review ECP. The reviewers review the proposal, looking for the additional information, if any, that was requested by the government at the TCM, and they take note of any issues that cross their mind as they complete the review. After the review is completed, the reviewer should attempt to resolve any issues that he may have by following the steps outlined below in the "Resolving Issues" paragraph. For those issues that remain outstanding, he should discuss them with the OPR and, if necessary, formally document those issues to the OPR (17). This review process is as important an activity for the government personnel to perform in a satisfactory manner because, if an ECP is poorly reviewed, either important considerations will remain unnoticed or the issue that could have been identified, worked, and corrected before the CCB may become an issue at the CCB (17). In either case, the consequences of an inadequate review are severe, resulting in either poor decisions on the part of the government or lost productivity due to CCB board members and others in attendance having their time wasted while issues that could have been resolved earlier are brought up, discussed, and go unresolved until the proper actions can be taken to clear up the issue.

Compile the Comments. As the SPO ECP OPR begins to collect the other directorates' comments, he can begin reviewing, compiling, and categorizing them. By reviewing the others' comments, he may be able to see some concerns that can be answered either by himself

or with the help of someone he knows. Compiling the comments will help him keep tabs of those who have not yet responded, and it will allow him to group similar concerns within categories, such as administrative concerns like dotting the "i's" and crossing the "t's", or more substantive content or process concerns. When he is through compiling all of the comments, including those from MDMSC and OCALC, he is ready to attempt to resolve any outstanding issues.

Resolve Issues. Before a reviewer provides a response to the OPR, he should try to resolve any issues he has with the proposal. First, he should discuss the concern with fellow SPO personnel, maybe even the OPR--perhaps someone else in the SPO has an answer to the question. Second, the government personnel at DCAS often have insight into the particulars of a proposed change. Recall that DCAS personnel attend many of the GD/C meetings, including those where future ECP submittals are discussed in detail, so consultation with them about the issue can prove quite productive. After exhausting government resources, if the issue is still not resolved, a call to the contractor is in order. Finally, if the discussion with the contractor is unproductive, the issue should be written u as an unresolved or unworkable issue and passed on to the ECP's OPR who will compile the comments from all of the other reviewers. The OPR should also attempt to resolve any outstanding concerns, to the best of his ability, before presenting the proposal to the CCB. Perhaps one of the most humbling experiences an OPR can experience is to be told that he has not properly worked all of the issues. Obviously, all issues cannot be worked by the directorate reviewers or the OPR; however, an attempt must be made. F those

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issues which remain outstanding even until the CCB, the decision to escalate the concern above the level to which it has been worked can be made by the CCB chairman (17).

Prepare ECP for CCB. The final step within this overall review process is to prepare the ECP for presentation to the CCB. The OPR should prepare briefing charts which will concisely describe the change; discuss the ramifications to cost, schedule, logistics supportability, and performance of the system whether or not the engineering change is implemented; the effectivity of the change (i.e., for which missiles will the change be implemented, and for which will it either not be implemented or be implemented at a later date via a retrofit); all outstanding issues and concerns; and the OPR's recommendation (17). The OPR must also indicate whether or not the change will impact MDMSC's efforts to produce "build to print" ACMs (17). Once the charts are prepared, the OPR is ready to present the ECP to the CCB for a disposition.

Disposition the ECP. The CCB has been mentioned at great length, and it was briefly described in Chapter I. However, a more detailed look at the CCB is now in order because the CCB determines the disposition of the ECP. In light of this, the approval/disapproval process will be discussed in conjunction with the CCB.

CCB Authority. In accordance with VC OI 800-1, the CCB has the authority to disposition ACM ECPs.

> The ACM CCB is an official joint command/agency group responsible
> for the control of all changes proposed to the scope of the con-
> tract. The System Program Director or designated alternate, as
> chairperson, is solely responsible for the approval or disapproval
> of a proposed change. (7:8)

CCB Membership. Membership on the CCB is established in VC OI 800-1, which states that

> CCB membership shall be limited to one primary member and one, or more, alternate member(s) from each directorate. Members and alternates shall be assigned by and identified on Special Orders. (7:8).

The OI goes on to state that membership will automatically consist of the System Program Director and the director from each directorate as the chairperson and primary board members, respectively, and that the director of VCC will fulfil the special role as CCB Secretariat (7:8).

General CCB Decision Rules. The CCB has been provided general guidelines by which it will normally base its decision:

> (1) Change proposals intended to incorporate improvements or increase system capability required to satisfy an operational requirement, contractual performance or design, or to correct a deficiency shall normally be approved.

> (2) Change proposals to incorporate improvements *not* required to meet present contract requirements or to increase capability beyond Program Management Directive (PMD) authorization shall normally be disapproved. (7:8)

CCB Procedures. VC OI 800-1 also provides general and specific CCB procedures. Namely, a CCB is usually held once each week at a set time; however, for ECPs needing immediate attention, the CCB chairperson can call a CCB meeting at any time (7:8-9). The OI continues:

> It is important to recognize that the following procedures identify the steps to be taken to ensure thorough evaluation of change proposals received. If expedited processing is required for a particular change proposal these steps must still be taken, the only difference is the amount of time permitted for total processing. the following procedures will be followed during the conduct of the CCB:

> (1) Each member, or their alternate, is responsible for providing to the CCB a Directorate recommendation on each change proposal to be reviewed. All comments/questions concerned with a

change proposal shall be provided to the OPR at least three days prior to the scheduled CCB. A copy of all comments shall be forwarded to VCC for inclusion in the official file.

(2) CCB attendance shall be documented by the signature of the CCBD [Configuration Control Board Directive, the form that indicates to the contractor whether or not the CCB was approved, plus any comments if appropriate]. If a directorate's primary and alternate members cannot attend the CCB, all CCBDs for that meeting will be annotated with the word "ABSENT" in the appropriate signature block.

(3) the CCB chairperson shall document the decision for each change proposal by signing all applicable sections of the CCBD. For ACSNs, the chairperson will personally sign the ACSN prior to submittal to the contractor. The CCBD shall reflect one of the decisions below:

(a) Approve the proposal as written.

(b) Approve the proposal contingent upon the incorporation of specific changes and submittal of either a change or revision to the change proposal as identified on the CCBD.

(c) Disapprove the change proposal. The reason for disapproval shall be stated on the CCBD.

(d) Defer the proposal for further investigation.

Once signed, the CCBD shall not be changed without approval of an amended CCBD by the chairperson.

Each member shall signify their concurrence with the decision by signing the CCBD at the completion of the CCB unless the member "non-concurs" with the chairperson's decision. In such cases, the dissenting member shall state their non-concurrence during the CCB and shall submit a letter, outlining the reason for non-concurrence, to the chairperson (a copy must be forwarded to VCC for inclusion in the official file) within three working days after the CCB meeting. Each non-concurrence shall be evaluated and a final decision shall be made by the SPO director. (7:9)

Incorporate the Approved Change. It is apparent that the CCB has specific procedures by which it is to disposition ECPs. Specific procedures also exist for what is to be done after a CCB decision is made. Basically, five steps must be performed after a CCB decision: notify the contractor of the decision, follow up on conditions of

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approval, participate in fact-finding and negotiating, ensure contractual agreements are finalized, and ensure the contractor takes the steps to implement the design change and update the required documentation.

Publicize the Decision. After the CCB, one of the first things to be done is to notify GD/C, MDMSC, DCAS, and OCALC of the CCB's approval decision regarding the ECP (17). This notification process is performed by preparing and completing the CCBD and sending it to these organizations (7:4). For an ECP that has been approved as written, the CCBD is the only document that needs to be sent out; however, if the disposition was anything but approval, then a document needs to be sent along with the CCBD that explains the CCB's decision in further detail (17). For example, if the ECP is dispositioned as "Approved with Comments," then a document needs to be attached to the CCBD that explains what the comments are.

Follow Up on CCBD Conditions. The OPR should expect a response from the contractor whenever comments are sent out with the CCBD. For an ECP that was Approved with Comments, the contractor would respond by submitting an updated copy of the ECP that incorporates all of the changes that were requested by the CCBD (17). If this updated copy includes all of the changes directed by the CCB, then the OPR and VCC may approve the changed submittal and the next process step, "fact finding" and "negotiation," may commence. However, a different response could be a contractual letter explaining why the contractor will not be able to comply with one or more of the comments, in which case the CCB can decide to either back off from its original requirement or hold firm to it (17). In any event, if the government and the contractor do not

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agree on a particular CCBD condition, then the remaining steps of the

incorporation process may get delayed until agreement is reached. Once

the government approves the ECP as presented by the contractor, fact

finding and negotiation, if necessary, may begin.

Fact Find and Negotiate (Contractual Review). The

cost of implementing engineering changes that are required to make the

hardware perform up to contractual specifications do not get added to

the contract because the costs to produce hardware to that specifica-

tion have already been negotiated into the original contract. However,

for those ECPs which make improvements to hardware over and above what

the contract previously stipulated, the contract base price may need to

be adjusted. But before the contract price gets adjusted, the costs

outlined in the ECP need to be studied by the government and, when

necessary, defended by the contractor. These processes are called "fact

finding" and "negotiation." Fact finding is an attempt by the govern-

ment to ensure that the costs outlined in the ECP are reasonable (17).

Costs that are identified as unreasonable are brought up to the contrac-

tor, who is allowed to attempt to justify those costs (17). A good,

sound fact finding effort can possibly save the government money, but

the converse if true also. When the fact finding effort is completed,

the final price can then be negotiated. For ease of discussion, these

two steps will be referred to simply as "contractual review" through the

remainder of this report.

Finalize Contract Modification. After a negotiated

price is reached, the final step, contract modification, can be accom-

plished. After the ECP is approved at the CCB and any CCBD issues have

been resolved, the OPR and a person from VCK work together to complete the fact finding, negotiation, and contract modification efforts. The OPR is still responsible for completion of all these steps; however, the OPR cannot adequately perform these jobs without assistance and involvement from the contracts representative, especially for this final ECP processing step. When the change is put on contract, the proposal becomes a contractually required task that the contractor must perform if it wishes to stay within the constraints of the contract.

Ensure Actual Implementation. Usually, the contractor does not need any encouragement to implement the approved change because, if the design change is one that corrects a design deficiency, the contractor knows that the government will not accept hardware without the incorporated change (17). However, there are times when the contractor may feel it is to his advantage to delay implementation of a change, in which case the OPR must monitor the contractor's progress and "encourage" him to make progress (17). Usually, only after the change is fully implemented is the OPR's responsibility with respect to that particular ECP relieved (17).

ECP and ECP Process Summary. This section has described the ACM SPO ECP process and it has described all of the steps in the process, from determining a need for a change to actual implementation of the change. Since the first hypothesis asserts that the ECP process is untimely, the reader needs to know how much time the ACM SPO believes it should take to implement an ECP through its process. The next section outlines these time goals.

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The Time Requirements

Although DOD-STD-480A provides no firm time requirement within which routine ECPs must be processed, the general guideline which the ACM SPO has historically followed is to take roughly 180 days to put a low-cost proposal on contract after the TCP is first received by the SPO (14). Within this general time frame, the ACM SPO and GD/C jointly developed a schedule and made the schedule a part of the contract between the two organizations (14). The schedule is included in ACM-DOC-301, the ACM Configuration Management Plan (CMP), which stipulates which organization is responsible for completing which steps of the process, from identification of the need for a change to the start up of the implementation process, and within how much time (14). These steps are described below and the amount of time allowed to complete them is shown in Table 2.

TABLE 2

REQUIRED TIMES FOR PROCESS STEPS

Organization	Step From	/ To	Number of Days
GD/C		/ Submit TCP	Begin
ACM SPO	TCP	/ Conduct TCM	14
ACM SPO	TCM	/ Submit ECP	38
ACM SPO	ECP	/ Conduct CCB	28
ACM SPO	CCB	/ Submit CCB Comments	7
GD/C	Comments	/ Submit Response	10
ACM SPO and GD/C	Response	/ Complete Review	40
ACM SPO and GD/C	Review	/ On Contract	10
Total for no-cost proposals			147
Total for proposals from $0 to $0.5 million			217
Total for proposals from $0.5 to $3.5 million			237
Total for proposals from $3.5 to $25 million			257

TCP to TCM. The ACM SPO has 14 days to review the TCP and conduct the TCM after it receives the TCP (9:3-2).

TCM to ECP. Within five days after the TCM, the contractor must submit TCM minutes which annotate the results of the TCM (9:3-2). The SPO then must approve those minutes as accurate (9:3-2). The contractor then has 33 days to submit the ECP to the SPO (9:3-2). If the SPO does not approve the minutes, then the contractor and the SPO must meet again to determine the proper course of action.

ECP to CCB. The SPO has 28 days to review the ECP and conduct the CCB (9:3-2a).

CCB to Complete Review. After the CCB, the two organizations have 57 days to complete the contractual review of a no-cost change (9:3-2a). During this time, the SPO has seven days to submit its CCBD and the contractor has 10 days to respond to the CCBD (9:3-2,3-2a). This response could either be a letter signifying acknowledgement of the CCB's decision to approve, defer, or disapprove the ECP, or it could be an updated or revised submittal of the ECP based on the CCB's decision to approve the ECP with comments (17). Then, for no-cost ECPs, GD/C has 30 days to submit a draft contract modification (mod) and the SPO has 10 days to review, comment on, and return the draft mod (9:3-2).

Complete Review to S/A. For no-cost ECPs, GD/C and the SPO have 10 days to formally sign the contract mod (9:3-2).

Total Time. Summing these individual step times produces the overall total time to complete the processing of a no-cost ECP: 147 days. The CMP allows more time to complete the proposal's processing as the cost of the proposed change goes up. Namely, as the costs rise, the

CMP provides more time for the contractual review steps (9:3-2). The CMP also allows extra time to put the proposal on contract after the review is completed (9:3-2). For a proposal costing from zero to one-half million dollars, 25 more days are allowed to complete fact finding, 20 more days to complete pre-negotiation efforts, and 25 more days to complete the negotiation process, totaling of 70 days (9:3-2). For proposals between $500,000 and $3.5 million, 15 extra days are allowed for the three additional review process steps plus five extra days are allowed to put the mod on contract, for a total of 20 extra days; and for proposals between $3.5 million and $25 million, 15 extra days are allowed for the review process and five extra days are allowed to put the mod on contract, for 20 extra days total (9:3-2). It is unclear what the specific ramifications are for either organization if one or the other fails to meet the time constraints established in the CMP, since no "penalties" are enforced when either organization fails to meet its time requirement (14). However, if delays exist, regardless of who causes the delay, the overall impact to the United States may be a delay in obta ..ing the needed level of deterrence.

Efforts to Improve Timeliness.

As the reader can imagine, based on the discussion above, the engineering change implementation process is quite complex and involves many people, especially when one considers that there are perhaps 90 or more outstanding ECPs at any one time in the ACM SPO that are in their various stages of the implementation process (17). This section addresses the researcher's and the ACM SPO's past efforts to improve the timeliness of the specific ACM SPO ECP process and the results of a

literature search for information regarding the efforts of other organizations to improve their internal ECP processes.

The Researcher's Efforts to Improve Timeliness. Because of the researcher's assignment in the ACM SPO, he became aware of the ECP process and the need to study it. This section addresses both the researcher's prior assignment in the ACM SPO and his previous attempts to improve the process.

Researcher's Assignment in the ACM SPO. This thesis topic did not come to the researcher "out of the blue." While a project manager in the ACM SPO from 14 November 1986 through 25 May 1989, the researcher was the ACM Retrofit Manager. A "retrofit" is a process which involves a change in configuration of a fielded weapon system (17). This change could be in the form of a removal and replacement with a new or different piece of hardware or software; removal, effecting the engineering change on the part that was removed, and reinstallation of the changed piece of hardware or software; or installation of a new piece of hardware or software (17).

Problem Recognition. Retrofits, by definition, imply change; those changes are approved through the ECP process (6:41-42). Furthermore, the ultimate configuration of the ACM was not yet stabilized, while the researcher was the retrofit manager, even though ACMs had been built. This instability was a result of concurrent design and production efforts which meant that production of hardware was implemented before all of the design work was finalized. So, because the researcher was the Retrofit Manager during a time of a changing

configuration, the researcher became quite intimate with the symptoms of the problems with the ECP process.

Attempts to Resolve Problems. Intimacy with the symptoms of the process problems bred a desire to fix the problems. So the researcher held meetings with various groups inside and outside the SPO attempting to work solutions to the untimeliness problems. The researcher discussed the issue with government personnel within the SPO and at OCALC and with contractor personnel, all of whom had a vested interest in resolving the untimeliness problem. Recommended solutions were proposed and implemented; however, the problems persisted. These proposed solutions, and the impact they had on the process once they were implemented, are presented next.

Specific Recommendations. Prompted by the researcher's perception that the ECP process could be more timely, the researcher made a recommendation to the CCB Chairman to begin using both a Technical Coordination Meeting (TCM) and a control to lower the incidence of OPR-induced delays in meeting the CCB.

Technical Coordination Meeting. Because the contractor was having difficulty submitting clearly defined and written proposals, the researcher felt that a meeting between the government and the contractor, before the ECP was submitted, could help solve the problem with the poorly written proposals. At this meeting, the organizations involved with the ECP process would review an informal copy of the yet-to-be-submitted ECP, called the Technical Change Package (TCP). The TCP would be presented as the technical portion of the ECP, including all of the technical details but none of the costs (7:7). The purpose of the

TCM was "to facilitate CCB action, speed the processing of the change, and provide understanding of change requirements between the contractor and the government" before the ECP was formally submitted (7:2). Specific steps were added into the SPO ECP process, but it was anticipated that these steps would diminish the total amount of time required to process ECPs, increase the quality of the result of the ECP process, or both. Recall from Table 2 above that the CMP allows the ACM SPO 14 days to review the TCP and another 38 days are allowed before the ACM SPO should receive the ECP. However, it was believed that these 52 extra days would possibly reduce the total processing time in the SPO, especially if the TCP review and TCM performed as they were intended.

Control Delays to CCB. A minor problem that existed in mid 1988 was the cancelling of appearances before the CCB, by the OPR, right before he was scheduled to present an ECP for approval. The CCB members took time to review copies of those ECPs scheduled for the next CCB so that they could make an approval recommendation to the CCB chairman. However, when OPRs cancelled their appointments with the CCB at the last minute, they effectively wasted the time the CCB members had devoted to be prepared to make their recommendation because, at the next CCB, the CCB members would have to take time to refresh their memories with the details of the ECP. Since no controls existed to curb the frequency of this event, it was believed that a minor control procedure could be implemented to help the situation. Thus a policy was put in place to require an OPR to obtain approval for a delay in a scheduled CCB appearance from the CCB chairman. This policy was implemented; however, the control measure seems to have since ceased to function as

it was intended (16). Both deputy program directors recently thought that the other deputy director was being asked for and approving delays in presentations; however, neither one was (16). The impact of these changes has been in question, as explained below.

Studying the Impact on Timeliness. One problem with these efforts is that the recommendations were made based mainly on perceptions about the ECP process, not on concrete data. Thus, there was not much data to confirm that the problem was diminished because of the implementation of the recommendations. Perhaps the lack of a rigorous study into the problems in the first place is why the problems persisted. At any rate, the purpose of the following efforts in the ACM SPO is to more rigorously study the process and develop measurement tools which will indicate a change in the timeliness of the process.

ACM SPO Efforts. The ACM SPO's efforts to improve the timeliness of the ECP process can be discussed in two phases.

First Phase. Since the timeliness and workload problems continued to exist, the ACM SPO formed a "critical process improvement team" (CPIT) in October, 1989 (16). This team, made up of government and contractor personnel, will attempt to improve the efficiency of the ECP process by first attempting to "come to a full understanding" of the current ECP process so that through understanding it might be able to implement techniques that will improve the efficiency of the process (16). The CPIT conducted a survey, using a questionnaire, within the ACM SPO to help the team understand the problems experienced by those individuals who were actively involved in the process. A copy of the survey is included in Appendix B, and partial results of this survey

will be included in Chapter IV. Furthermore, VCC has been involved with these efforts by being active members of the CPIT and by developing an operating instruction, VC OI 800-1, which outlines the major require-ments of all the ECP process players in the SPO and provides guidelines as to how long the steps in the process should take; the OI time guide-lines are slightly more ambitious than the times stated in the CMP (5). Furthermore, the CPIT, after studying the ECP process, will make recom-mendations that may improve the process' timeliness and effectiveness.

Second Phase. Finally, the second phase is represented by the researcher's new efforts at quantifying the ECP process in conjunc-tion with the efforts of the CPIT. The researcher will perform the steps outlined in Chapter III so that specific recommendations can be made to improve the timeliness of the ECP process.

Efforts of Others to Improve Their ECP Process. To determine what other organizations have done to improve the timeliness or efficiency of their configuration change approval process, a search of the literature was performed. The Defense Technical Information Center (DTIC) searched government technical reports for the key words "engineering/modifica-tion," and DIALOG searched the public literature for the key words "production, engineering, and (configuration or design) changes." This search produced nothing dealing with efforts to improve the engineering design change process.

Chapter Summary

Chapter I presented specific hypotheses about the timeliness of the ECP process and the ability of the SPO to effectively perform the ECP process. This Chapter provided the background information needed to

fully explain the hypotheses. Included in this chapter were

descriptions of the ACM SPO, the outside agencies the ACM SPO works with

when processing ECPs, the ECP and the ECP process steps and time

requirements within the SPO, and the researcher's and others' prior

efforts to improve the timeliness of the ECP process. Chapter III now

will address the specific steps that the researcher will follow to test

his hypotheses. The results of these tests will be presented in

Chapter IV and they will be used to make the recommendations that will

be presented in Chapter V.

III. Methodology

Now that the background information has been presented, this chapter will provide the methodology that will be used to test the hypothesis about the process timeliness and the four hypotheses that claimed that specific problems exist with the ECP process. For each hypothesis, the discussion will follow the same general flow. Namely, focus questions (FQs) will be developed that convert the hypothesis statements into yes or no questions; assumptions will be stated, the specific methods used to determine the answer to the focus question will be described, and the null and alternate hypotheses will be provided. The chapter is divided into two sections. The first section develops the techniques for measuring the process timeliness, and the second section develops the methods that will be used to confirm or deny the hypothesis claims about the process problems.

Timeliness of ECP Process

Recall that the first hypothesis states simply that the ACM SPO ECP process is not timely. This hypothesis will be tested using five focus questions (FQs). For each FQ, the assumptions, methods, and null hypotheses are presented. These five FQs include the following. 1) Is the ACM SPO ECP process taking too much time to complete? 2) Are ECP process steps taking too much time? This question will be addressed to each process step to determine which ones are untimely. 3) Are ACM SPO ECPs being routed through the same process steps more than one time? 4) Are there any specific ECP process flow paths that are more timely

than the times presented in the CMP? 5) Is there a disproportionate number of open ECPs awaiting processing in any of the ECP process steps? Figure 8 below shows the general order of the following discussion. If the first focus question is answered positively, then the four other focus questions will be answered to perhaps identify specific process steps as problem areas.

FQ Number 1. Is the ACM SPO ECP process taking too much time? This FQ is the major question in this study. All of the following FQs are based on the assumption that the answer to this question is "yes."

Assumptions for FQ Number 1. Six assumptions will be made to answer this focus question.
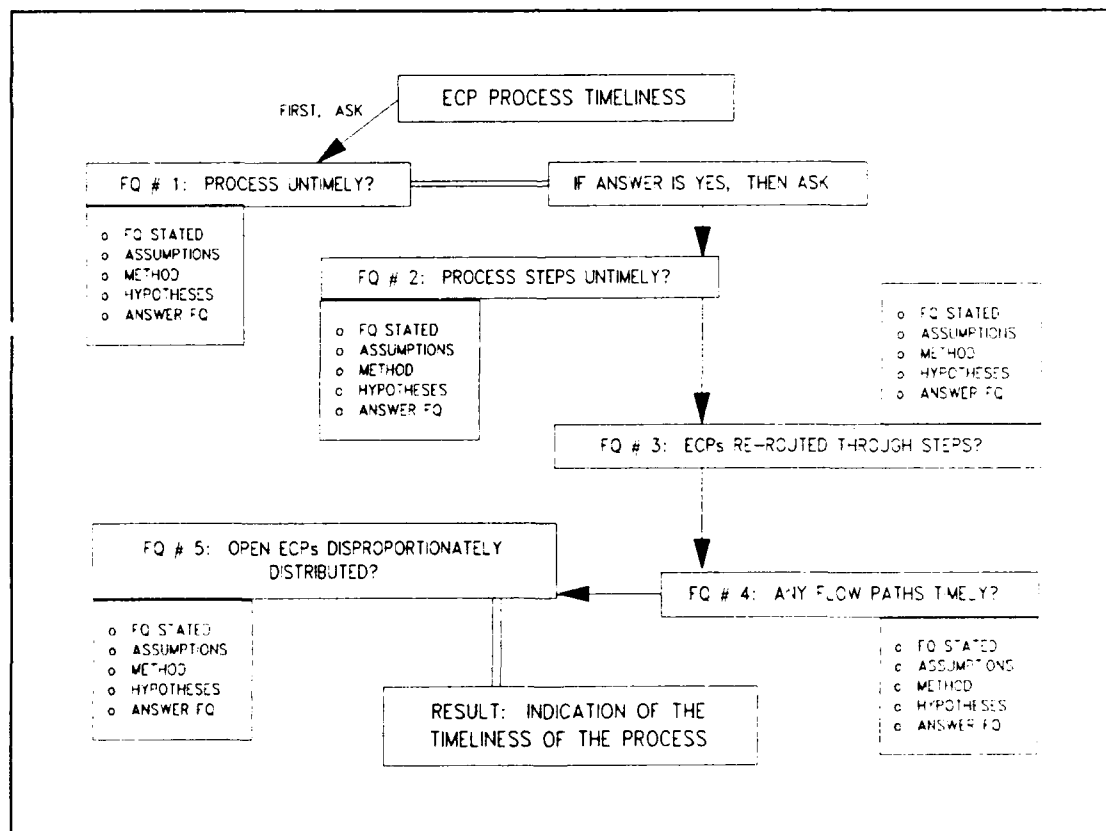
Figure 8. Discussion Flow for Determining Process Timeliness

One. Table 3 below restates, according to the CMP, how much time ECPs should take to be processed from TCP receipt to supplemental agreement. The first assumption is that the time provided by the CMP is an appropriate measure with which to compare the timeliness of the ECP process in the ACM SPO. So, if the actual process times, as determined using the methods presented below, are less than or equal to those spelled out in the CMP, then the process will not be considered untimely. However, if the actual process times are more than the CMP times, then the answer to the FQ will be "yes." This assumption essentially ignores, for the moment, one key point: the CMP time standard could be too aggressive. In other words, perhaps the ECPs are not being processed within the CMP time constraints because the CMP is too optimistic in how much time an ECP should take to be processed.

TABLE 3

PROCESS STEP TIMES STIPULATED IN THE CMP (9:3-2)

	Number of Days
Total for no-cost proposals	147
Total for proposals from $0 to $0.5 million	217
Total for proposals from $0.5 to $3.5 million	237
Total for proposals from $3.5 to $25 million	257

Two. The amount of time allowed in the CMP for processing no-cost ECPs will be used as the standard to answer this focus question. Thus the actual processing time of the selected ECPs will be compared to the value of 147 days (9:3-2).

Three. The second assumption above stipulates that only no-cost ECPs will be studied. In addition to this limitation, the universe from which ECPs will be chosen will be narrowed even more by selecting only those ECPs that were approved; were processed with the benefit of TCP Receipt, TCP Review, and TCM process steps; and had any activity, from TCP receipt to supplemental agreement, during the seven month period from June 1, 1989 to December 31, 1989. The assumption here is that this sample of ECPs will provide a true picture of the overall ECP process timeliness regardless of the cost of the ECP. Additionally, the data collected with this time criteria will be assumed to be representative of the process as it existed not only in the last seven month period of 1989, but also through July 1990.

Four and Five. The data will be collected from individual ECP reports that are produced by a computer database program. These reports are updated periodically by the OPR and the VCC Change Manager. The fourth assumption is that the selected reports constitute a random sample that is representative of the true situation. Furthermore, the fifth assumption is that these reports are accurate and up to date; inaccurate and dated material will impact the results of the study.

Six. Statistics, including the sample mean and sample standard deviation, will be computed using the set of the number of days the ECPs took to be processed. Since the sample size will be greater than 30, the sixth assumption is that the Central Limit Theorem applies; thus the sample mean is approximately normally distributed, the expected value of the sample mean is equal to the population mean, and the sample

variance is equal to the population variance divided by the sample size (11:213). This assumption allows the researcher to use the z distribution to compute the 90% one-sided confidence interval described below.

Method for FQ Number 1. The FQ will be answered by comparing the actual times to complete the processing of ECPs to the amount of time stated in the CMP.

Collect the Data. The data will be collected from ECPs that never were considered as cost ECPs, that first arrived in the SPO as a TCP, that completed all steps necessary to be put on contract, and that had any activity, from TCP receipt to supplemental agreement, during the last seven months of 1989. The data that will be collected are, for each individual ECP, the ECP number and the actual dates of two milestone events. These two milestone completion dates are the date when the ACM SPO received the TCP and the date the ECP was made a part of the contract. These two dates will be will be used to compute the time it takes the ACM SPO to process ECPs from TCP receipt to S/A.

Manipulate the Data. For each ECP, the two milestone dates will be put into a QUATTRO PRO spreadsheet. The "@DATEVALUE-(string)" function will be used to convert the dates into numerical equivalents. For example, by entering the dates as text strings in the format of Month/Day/Year, the @DATEVALUE(string) function can be used to determine the number of days, by taking the difference between the two numerals, that the SPO took to put the change on contract after the SPO received the TCP (4:30). The result will be a table consisting of a column of numbers in the spreadsheet that represent the number of days the ECPs took to be processed.

<u>Determine the Sample Statistics</u>. Next, QUATTRO PRO's @AVG and @STDS functions will be used to determine the sample mean and sample standard deviation of the data. These sample statistics will be used to calculate a 90% one-sided confidence interval to the numerically lower side of the sample mean. The lower bound value (LBV) of this interval will be computed using Equation 1:

$$LBV = MT - Z\alpha * (S/\sqrt{n}) \tag{1}$$

where MT is the sample mean time, $Z\alpha$ equals 1.282 based on a 90% one-sided confidence interval, S is the sample standard deviation, and n is the number in the sample (11:634). The significance of the lower bound value is that there is a 90% probability that the population mean is above it, and a 10% chance that the population mean is below it.

<u>Null and Alternate Hypotheses, FQ Number 1</u>. The parameter of interest is $\mu 1$, defined as the population's mean ECP processing time. The null hypothesis is

$$Ho: \mu_1 \leq \mu_0 \tag{2}$$

and the alternate hypothesis is

$$Ha: \mu_1 > \mu_0 \tag{3}$$

where μ_0 is the null value (the standard) of 147 days based on the CMP stated time for no-cost proposals to be processed from TCP receipt to supplemental agreement (9:3-2). This alternate hypothesis calls for an upper-tailed test because a large test statistic value, which represents the value above which the population mean exists, will tend to refute the null hypothesis (11:281). Indeed, if the LBV is higher than μ_0, then the data indicates with 90% certainty that the population's processing time is greater than the standard time presented in the CMP.

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Thus the value of LBV will be used as the test statistic value to test the null hypothesis, and it will be computed using Equation 1 above. Thus, we accept the null hypothesis when the lower bound value of the 90% one-sided confidence interval is less than or equal to the CMP standard time, and we reject the null hypothesis if the LBV is higher than the CMP standard time. If the null hypothesis is rejected, then the data indicates that the ECP process is taking more time than the CMP allows, possibly because the process is untimely.

Answer FQ Number 1. The calculated LBV will be used to answer the focus question. Namely, if the LBV is less than the time stated in the CMP, then the answer to the FQ is "No, the ACM SPO ECP process is not taking too much time." However, if the time stated in the CMP is less than the LBV, then the answer to the FQ is "yes." A bar chart will be constructed which will pictorially show the answer to the focus question. As an example, Figure 9 includes two vertical bars; the left bar's height represents the number of days the CMP allows for processing no-cost ECPs, and the right bar's height represents an example of the mean number of days the sample ECPs could have taken to be completed. The lower bound value is represented by the lower edge of the shaded region. Also, the relationship between the LBV and the top of the left bar provides a visual answer to the focus question. For example, if the lower edge of the shaded region is above the top of the left bar, then, with 90% confidence, the population average is above the standard time and the answer to FQ Number 1 is yes, the process is indicated as untimely. However, remember the caveat presented above with the first assumption: the answer may be "yes, the process is

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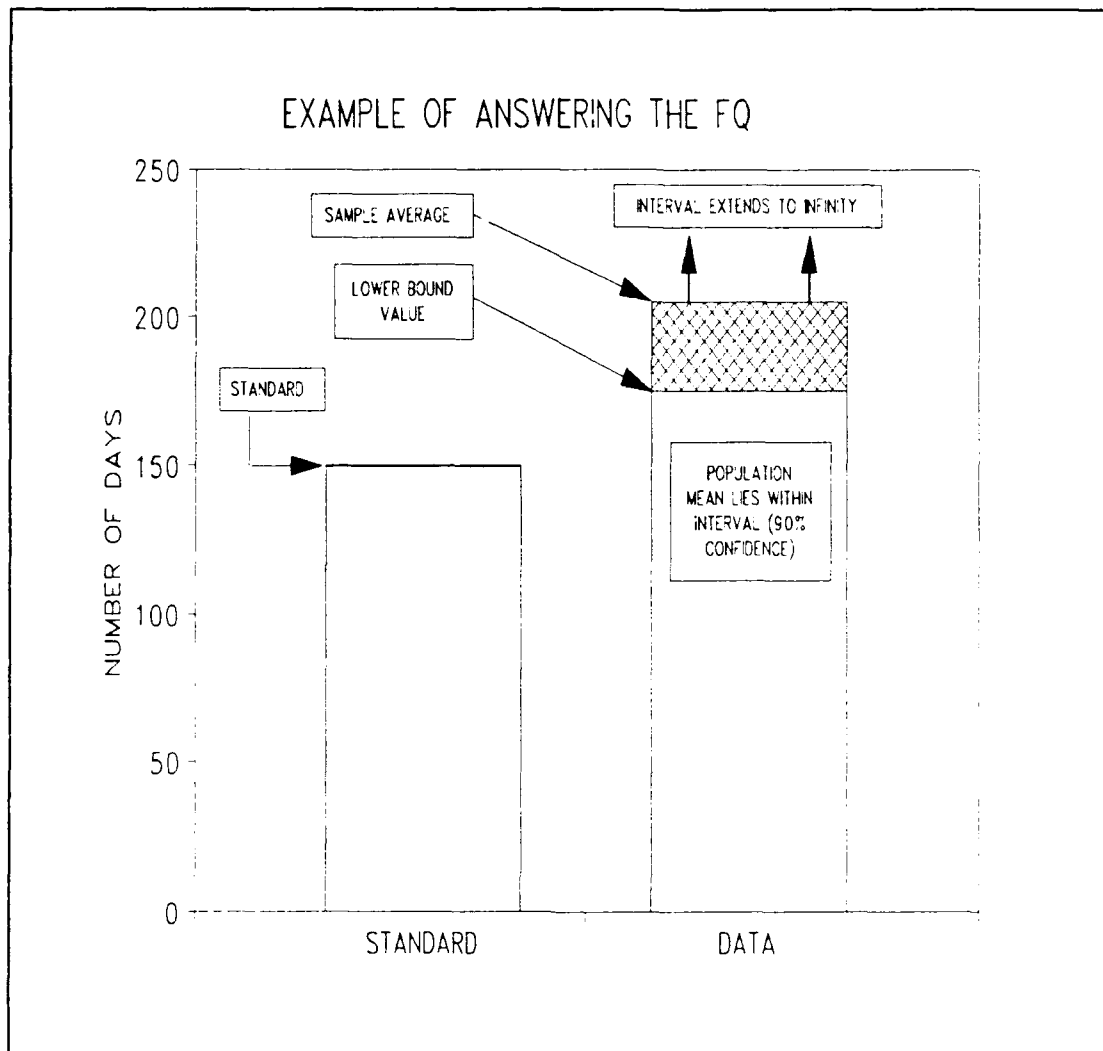
Figure 9. Example of Bar Chart Showing Confidence Interval

untimely," but the answer is based on the assumption that the time requirements stated in the CMP are reasonable and achievable. Now, if the null hypothesis is rejected, then the following four FQs will need to be answered.

FQ Number 2. Are individual process steps taking too much time? A positive answer to this question will tend to indicate a timeliness

problem within a specific processing step. This FQ will be asked for each ECP process step.

Assumptions for FQ Number 2. Seven assumptions will be made to answer this focus question.

One. The first assumption is that the CMP is an appropriate measurement tool to use to compare the timeliness of the ECP process.

Two. The second assumption states that the collected data is representative not only of the process as it existed in the seven month time window from which the data was collected but also of the process from the end of that seven month window through July 1990.

Three and Four. The reports from which the data was collected are both accurate and current, and the data constitutes a random sample from the population of all ECPs processed by the ACM SPO. This sample includes all ECPs which had any activity within the last seven months of 1989 regardless of cost, disposition, or whether or not a TCM was conducted.

Five. Statistics, including the sample mean and sample standard deviation, will be computed using the set of the number of days each process step took for each ECP. A 90% one-sided confidence interval and the interval's LBV will be calculated for each process step. This interval will be calculated differently based on the sample size. If the sample size is greater than 30, then the Central Limit Theorem will be invoked and the sample mean will therefore have an approximately normal distribution; the confidence interval then will be able to be computed using the z distribution (11:295).

Six. If the sample size is less than 30, then an assessment will be made to determine the data's distribution shape. A computer program, Statistix, will be used to perform a Wilk-Shapiro test of normality, producing a rankit plot of the variable [process time] and computing an approximate Wilk-Shapiro normality statistic called the Shapiro-Francia statistic (22:8.4). "If the sample conforms to a normal distribution, a plot of the rankits against the order statistics should result in a straight line, except for random variation" (22:8.5). The sixth assumption is that if the data produces an estimated Wilk-Shapiro value of greater than 0.90 and if the rankits plot follows a linear pattern, then the data will be assumed to follow the normal distribution.

Seven. If, however. the rankits plot is not close to linear, based on visual inspection, or if the Shapiro-Francia number is below 0.90, then the researcher will conduct a Kolmogorov-Smirnov (K-S) test to determine if the shape of the distribution is exponential. In regards to the K-S test's applicability, Law and Kelton state

> ... the original form of the K-S test is valid only if all the parameters of the hypothesized distribution are known; i.e., the parameters cannot have been estimated from the data. In recent years, however, the K-S test has been extended to allow for estimation of the parameters in the cases of normal, exponential, and Weibull distributions. (20:199)

The researcher does not know what the population parameters are, so the parameters will be estimated. These estimates will be used to determine the adjusted K-S test statistic which will then be compared to critical values (CVs), given by Law and Kelton, for a 90% confidence factor. For the exponential distribution, the CV is equal to 0.990 (20:201). If the calculated adjusted test statistic, which is computed according to the equations presented by Law and Kelton, is less than the CV, then the

test will have indicated a good fit (20:201). Thus the seventh

assumption is that if the adjusted K-S statistic is less than 0.990,

then the data will be assumed to follow the exponential distribution.

Method for FQ Number 2. The FQ will be answered by

comparing the actual times to complete each individual process step to

the amount of time each step is allowed in the CMP. The comparison will

be made by determining the lower bound value of a 90% one-sided

confidence interval about the means of the data and seeing whether or

not the LBV is higher than the value of the time stated in the CMP. If

the LBV is higher than the CMP value, then the data will tend to

indicate an untimely process step (remember the first assumption).

Collect the Data. The data that will be collected for

each individual ECP are listed in Table 4. Table 4 also shows what

other identifying information will be collected.

Manipulate the Data. For each ECP, the milestone

dates will be put into a QUATTRO PRO spreadsheet and the

"@DATEVALUE(string)" function will be used to convert the dates into

numerical equivalents. These numerals will then be subtracted to

determine the number of days that were required to complete each ECP

process step. The result will be a table (in the spreadsheet)

consisting of multiple columns of numbers that represent the number of

days the ECPs took to be processed at each process step.

Determine the Sample Statistics. Next, QUATTRO PRO's

@AVG and @STDS functions will be used to determine the sample mean and

sample standard deviation of the data for each process step. These sta-

tistics will be used to determine the LBVs of a 90% one-sided confidence

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TABLE 4

DATA THAT WILL BE COLLECTED TO ANSWER FQ 2

Identifying Information

ECP Number: the peculiar number for each ECP
OPR's Org Symbol: for example, "VCA" for Projects
Cost Information: Proposed cost and final negotiated cost

Milestone Events for Which Dates Will Be Collected

TCP Receipt: date the TCP is received by the SPO
TCM: date the TCM is conducted
ECP Receipt: date the ECP is received by the SPO
CCB: date the proposal is briefed to the CCB
GD/C Response: date the contractor responds to the CCB comments
OPR Approval: date the OPR approves the CCB-directed updates
Review Comp: contractual review process completion date
S/A: date the change is formally put on contract

interval to the numerically lower side of the sample mean. However, the
value of the LBV depends not only on the distribution shape of the data
but also on the sample size. Three combinations of distribution shape
and sample size exist, driving a requirement to determine the LBV using
three different equations. These three combinations are discussed now.

Sample Size 30 or More. When the sample size is
30 or more, then the lower bound value of the confidence interval is
determined using Equation 1 above.

Normal Distribution, Sample Size Less Than 30.
When the sample size is less than 30 and the distribution has been
determined to be approximately normal, then the lower bound value of the
confidence interval is determined using Equation 4 below:

$$LBV = MT - t(\alpha, v) * (S/\sqrt{n}) \tag{4}$$

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where $t(\alpha,v)$ is equal to the t critical value based on the confidence factor α and the number of degrees of freedom v, where $v = n-1$ (11:268). For a 90% one-sided confidence interval, α is equal to 0.10, so the t critical value can be read off Table A.5 in Devore's text (11:267).

Exponential Distribution. When the shape of the distribution cannot be declared approximately normal, then the adjusted K-S statistic will be computed. The researcher will calculate the K-S statistic, using MathCAD software, in accordance with the method outlined by Law and Kelton on pages 199 through 203 (20:199-203). If the adjusted K-S statistic confirms that the data is approximately exponential, then the lower bound value of the 90% one-sided confidence interval will be calculated using Equation 5 below:

$$LBV = (2 * \Sigma x_i) / y^2 \tag{5}$$

where "Σx_i" is the sum of all of the times for each process step and y^2 is the chi-squared critical value based on the number of elements in the data set and the desired confidence (11:257-258). Table A.6 from Devore's text will be used to determine the chi-squared number for sample sizes less then 20; for sample sizes greater than 20 the chi-squared critical value will be estimated (11:636).

Null and Alternate Hypotheses, FQ Number 2. The parameter of interest is μ_2, defined as the population's mean ECP processing time for each process step. The null hypothesis for each step is

$$Ho: \mu_2 \leq \mu_0 \tag{6}$$

and the alternate hypothesis is

$$Ha: \mu_2 > \mu_0 \tag{7}$$

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where μ_0 is the null value (the standard) of the number of days the CMP

states the process step should take to be completed. The null values

are repeated in Table 5 below. The alternate hypothesis calls for an

TABLE 5

PROCESS STEP NULL VALUES

Process Step From / To	Number of Days (No-Cost)	Number of Days $(0 \leq 0.5)$	Number of Days $(.5 \leq 3.5)$	Number of Days $(3.5 \leq 25)$
/ Submit TCP	Begin			
TCP / Conduct TCM	14	14	14	14
TCM / Submit ECP	38	38	38	38
ECP / Conduct CCB	28	28	28	28
CCB / Submit CCB Comments	7	7	7	7
Comments / Submit Response	10	10	10	10
Response / Complete Review	40	85	100	115
Review / On Contract	10	35	40	45
Total for no-cost proposal	147	217	237	257

upper-tailed test because a large test statistic value, which represents

the value above which the population mean exists, will tend to refute

the null hypothesis (11:281). Indeed, if the LBV is higher than μ_0,

then the data will indicate with 90% certainty that the population's

processing time is greater than the standard time presented in the CMP.

Thus the test statistic value that will be used to test the null

hypothesis is the value of LBV, computed from Equation 1, Equation 4, or

Equation 5 above. And, we accept the null hypothesis when the lower

bound value of the 90% one-sided confidence interval is less than or

equal to the CMP standard time, and we reject the null hypothesis if the LBV is higher than the CMP standard time. If the null hypothesis is rejected, then the data indicates that the ECP process is taking more time than the CMP allows, possibly because the process step is untimely.

Answer FQ Number 2. Using the calculated LBV, the answer to the FQ for each process step can be determined. So, if the LBV is lower than the stated CMP time for the specific process step, then the answer to the FQ is "No, this specific ECP process step is not taking too much time." However, if the time stated in the CMP is less than the LBV, then the answer to the focus question is "yes."

FQ Number 3. Are ACM SPO ECPs being routed through the same process steps more times than once? A positive answer to this question could be indicative of inefficiencies in either the SPO's TCP and TCM review process or in the contractor's ability to update the ECP according to the requirements established by the personnel at the TCM or in the CCBD. Of course, a positive answer to the focus question also could mean that the environment is causing instability in process such that the needs change between the time the ECP is submitted to the SPO and boarded at the CCB.

Assumptions for FQ Number 3. Three assumptions will be made to answer this focus question.

One. Although the CMP's Change Proposal Flow indicates that a possibility exists of having to change the ECP based on comments from the CCB, it does not provide any time requirements within which the proposal steps should be re-accomplished (cmp:3-2a). The CMP ideal flow is shown in Figure 10; it is identical to the ACM SPO ECP

flow presented in Figure 7 in Chapter II except the OPR Approval step loop in Figure 7 is omitted from Figure 10; this additional loop is not included because those steps are not a part of the ideal flow. Thus, the first assumption is that the ideal flow is as shown in Figure 10; where no process steps need to be performed more than once. Furthermore, this ideal flow will be the baseline requirement against which the actual process flow frequencies will be compared.

Two, Three, and Four. The second assumption is that the collected data is representative not only of the last seven month period of 1989 but also of the period up to and including July 31, 1990. The third assumption is that the data will represent a random sample, and the fourth assumption is that the reports from which the process flow data will be collected are both accurate and current.

Method for FQ Number 3. The FQ will be answered by determining the frequency at which ECPs must re-accomplish certain steps in the ECP process. The frequencies will be determined by dividing the number of times ECPs must re-accomplish certain process steps by the total number of ECPs that "arrive" at a decision point. The researcher will study two decision points including the CCB, which determines the disposition of the ECP, and the OPR Approval decision point, which is where the OPR determines whether or not the ECP was updated according to the CCBD. If the frequencies are relatively high, then the data will be indicative of a process that possibly includes a lack of effort on the part of the SPO during the TCP review process or at the TCM, or a lack of ability of the contractor to follow through with the requirements stated in the CCBD (perhaps because it is not written clearly).
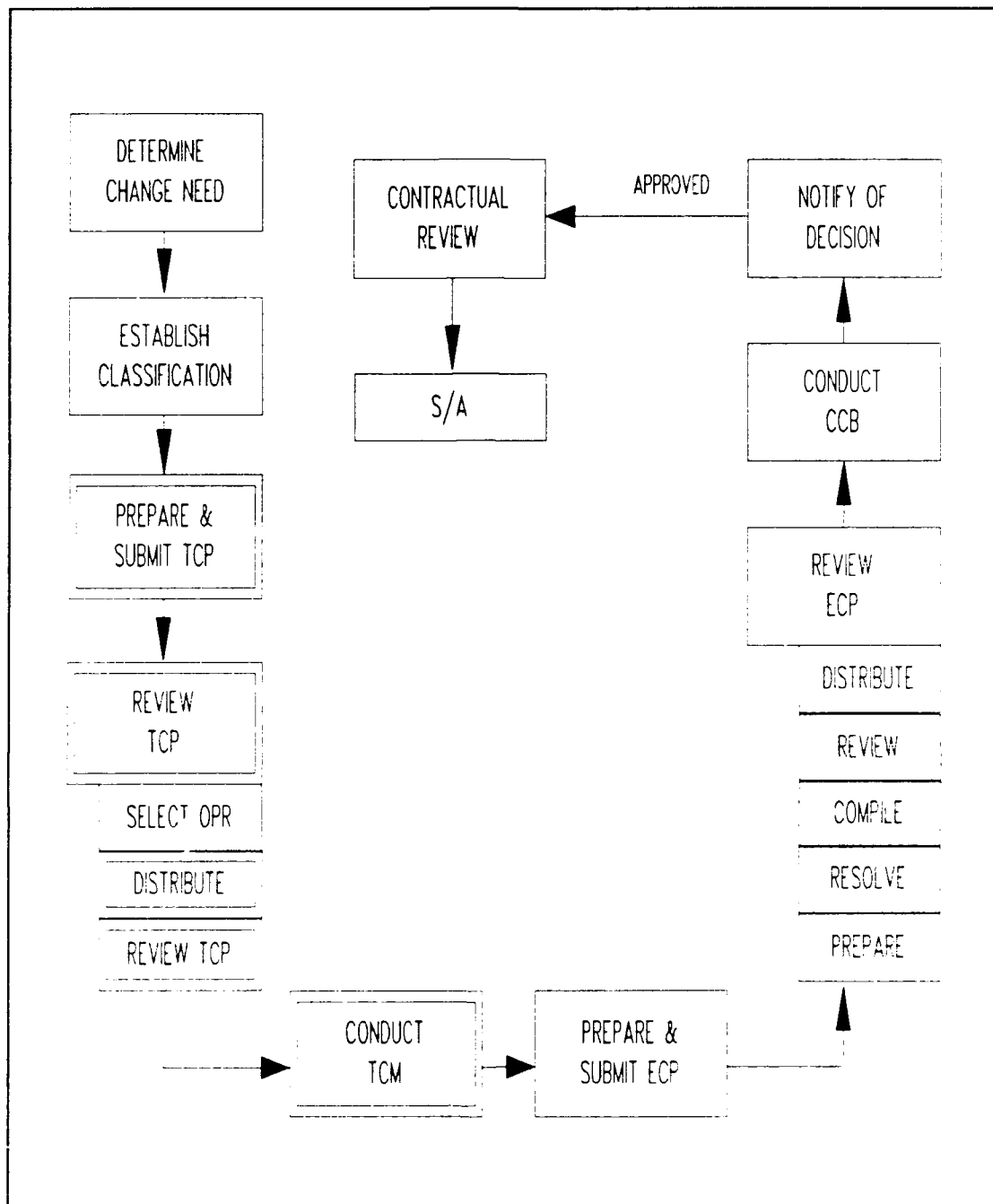
Figure 10. Ideal ECP Flow as Presented in the CMP (9:3-2)

Collect the Data. The data that will be collected
are, for each individual ECP, the sequence of milestone events that the
ECP went through before it completed its processing. For example, the

data will take on the form of a list of milestone events that could include the following: TCP Receipt - TCM - ECP - CCB - ECP - OPR Approval - Review - S/A. For this example, the ECP process flow included the receipt in the SPO of a TCP; the SPO conducted a TCM; the TCM comments and recommended changes, if any, were incorporated into the TCP and the TCP was then submitted as the technical portion of the ECP (the cost volume, for a cost proposal, also will be prepared and submitted at this time); the SPO and the other organizations, including SAC, OCALC, and MDMSC, reviewed the ECP and provided comments to the OPR who then briefed the ECP to the CCB; comments were generated in the CCB, included in the CCBD, and sent to the contractor who updated the ECP with the changes and resubmitted the ECP to the SPO; the OPR approved the changed ECP as submitted; the contractual review process was completed; and the ECP was made an official contractual change. If the process flow includes an OPR Approval step, then the contractor's submission of the ECP required changes that possibly should have been found and corrected during the TCP Review and TCM process steps.

Manipulate the Data. For each ECP, the flow path will be determined. The individual flow paths will then be compiled onto flow charts which will indicate all possible routes the chosen ECPs went through to complete processing and how often those routes were accessed.

Determine the Sample Statistics. Next, two frequencies will be computed. The first frequency is computed by dividing the number of times ECPs are Approved with Comments by the number of ECPs that met the CCB. This frequency will tend to indicate how well the TCP Review and TCM process works, since it is assumed that if the TCP Review

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process is functioning correctly then most problems, concerns, and typographical errors will be addressed and corrected at the TCM. The second frequency that will be computed is determined by dividing the number of times the OPR does not approve the ECP submittal at the OPR Approval decision point, but instead requires the contractor to make additional changes to the ECP before it is approved, by the number of ECPs that reach the first OPR Approval decision point. A relatively high frequency here will tend to indicate the possibility of inadequate communication between the ACM SPO and the contractor or the inability of the contractor to update the ECP as requested. Based on the researcher's subjective evaluation of the ECP process in the ACM SPO, plus through the researcher's personal experiences and informal discussions with ACM SPO personnel, the researcher believes that the state of the process in the SPO is such that 70% or more of the ECPs should be Approved at the CCB the first time the ECP is presented to the CCB. To expect a much higher percentage of Approved ECPs would be an unreasonable expectation. However, the researcher believes that at least 80% of the ECPs that go to the OPR for approval should be approved, without having to be sent back to the contractor for additional editing.

Null and Alternate Hypotheses, FQ Number 3. The parameters of interest are pa and pb, where pa is defined as the proportion of ECPs that are Approved with Comments at the CCB and pb is defined as the proportion of ECPs that the OPR does not approve at the OPR Approval step. The "test" that will be employed here is to compare values of pa and pb to the researcher's subjectively determined percentages of 0.30 and 0.20, respectively.

Answer the FQ. Using the frequency data, the answer to the FQ will be determined. Namely, if the frequency with which ECPs get Approved with Comments is greater than 0.30, then there answer to the focus question will be "yes, a significant percentage of ECPs are not following the ideal process flow." Furthermore, if the frequency with which ECPs must be processed through the OPR Approval step is greater than 0.20, then a problem is indicated. Thus, if the values of pa and pb are higher than the subjectively determined values, then the data will tend to indicate possible problems with the TCP Review and TCM steps, the contractor's ability to update the documents as requested, or some other problems.

FQ Number 4. Are there any specific ECP process flow paths that are more timely than the CMP requirements? This question is different from the first FQ because the answer to this question requires the comparison between the actual times for groups of ECPs that share in common the specific flow path taken and the amount of time provided in the CMP for an ECP following th. path. For example, ECPs that are disapproved at the ECP should take less time to process than ECPs that are approved because disapproved ECPs typically do not have to go through the Contractual Review process steps.

Assumptions for FQ Number 4. Five assumptions will be made to answer this focus question.

One. The first assumption is that the CMP is an appropriate measurement tool to use to compare the timeliness of the specific ECP process flows. Thus, if the actual process times, as determined using the methods presented below, are less than those

spelled out in the CMP, then the process flow will not be considered untimely. However, if the actual process flow times are longer than the CMP times, then the answer to the IQ will be "yes."

Two, Three, and Four. The second assumption is that the collected data will be representative of the process as it has existed through July 1990, the third assumption is that the collected data constitutes a random sample, and the fourth assumption is that the reports from which the process flow data will be collected are accurate and current.

Five. Statistics, including the sample mean and sample standard deviation, will be computed using the set of the number of days each group of ECPs took to be processed. A 90% one-sided confidence interval will be calculated. The fifth assumption is that the collected data follows the normal distribution. An assessment of this assumption will be made using Statistix's Wilk-Shapiro test of normality. If the Shapiro-Francia statistic is higher than 0.90 and if the rankits plot is approximately linear, then the data will be determined to follow the normal distribution (22:8.5).

Six. If, however, the distribution cannot be assumed to be normal, the researcher will conduct a K-S test to determine if the shape of the distribution is exponential. For the exponential distribution, the critical value is equal to 0.990 (20:201). If the calculated adjusted K-S test statistic is less than the CV, then the test will indicate a good fit (20:201). Thus the seventh assumption is that if the adjusted K-S statistic is less than 0.990, then the data will be assumed to follow the exponential distribution.

Method for FQ Number 4. The FQ will be answered by comparing the actual times to complete process flows to the amount of time allowed in the CMP for ECPs following that flow path.

Collect the Data. The data that needs to be collected includes, for each ECP, the ECP number and the dates when the first TCP or the first ECP (for ECPs that do not have a TCP) is submitted to the ACM SPO and when the ECP completed its processing by either being put on contract or by notifying the contractor that the ECP has been disapproved at the CCB.

Manipulate the Data. The ECPs will be grouped according to the specific path that the ECPs followed. Nine separate paths will be considered. Table 6 below indicates the paths that will be studied.

TABLE 6

PROCESS FLOW PATHS AND CMP TIMES TO COMPLETE (9:3-2)

Path Number and Process Flow	Number of Days Allowed, CMP
1. TCP-TCM-ECP-CCB-ECP-OPR-REV-S/A	147
2. TCP-TCM-ECP-CCB-ECP-OPR-OPR-REV-S/A	147
3. TCP-ECP-CCB-ECP-OPR-REV-S/A	147
4. TCP-TCM-ECP-CCB-REV-S/A	147
5. TCP-TCM-ECP-CCB-COMM OUT	97
6. TCP-TCM-TCP-TCM-ECP-CCB---COMPLETION	147
7. ECP-CCB---S/A	95
8. MISCELLANEOUS	95-147
9. ENTRY-----COMPLETION	95-147

Note: time allowances assume the ECP is a no-cost change.

1.	TCP-TCM-ECP-CCB-ECP-OPR-REV-S/A, where a TCP was received, a TCM was held, the ECP was submitted and then boarded at the CCB, the proposal was Approved with Comments, the ECP was updated and submitted to the SPO, the OPR approved the updates, the Review process was completed, and the change was put on contract

2.	TCP-TCM-ECP-CCB-ECP-OPR-OPR-REV-S/A, where an ECP followed Path 1 but had to have a second OPR approval step. In other words, after the CCB, the contractor updated the ECP, submitted it to the SPO, but the OPR did not approve the contractor's updates. The lack of approval forced the contractor to edit the ECP and submit it to the OPR for the second time after the CCB before the ECP could progress to the Review process steps.

3.	TCP-ECP-CCB-ECP-OPR-REV-S/A, where the only difference between this path and Path 1 is that the TCM was waived.

4.	TCP-TCM-ECP-CCB-REV-S/A; this path represents the ideal flow, where the ECP is approved as written at the CCB.

5.	TCP-TCM-ECP-CCB-COMM OUT, where these proposals were disapproved at the CCB. The COMM OUT date is recorded after the CCBD is approved for release to the contractor.

6.	TCP-TCM-TCP-TCM-ECP-CCB---COMPLETION, where these ECPs cycled through two TCPs and two TCMs and, after the CCB, followed various routes to completion (for example, multiple additional presentations to the CCB or multiple OPR Approval steps were required).

7.	ECP-CCB---S/A, where these ECPs arrived for the first time in the SPO in the form of an ECP, not a TCP. After the CCB, these ECPs followed different routes to the supplemental agreement step.

ECPs that are classified as "Urgent" or "Emergency" type ECPs would be expected to follow this path because of the time requirements to process these types of ECPs (6:16). In fact DOD-STD-480A stipulates a target of 15 calendar day to put an "Urgent" proposal on contract and a target of only 24 hours to put an "Emergency" proposal on contract after the proposal is received; however,

> The criticality of the need for decision will dictate the actual processing time for Emergency and Urgent ECPs. Emergency and Urgent ECPs should be proposed based upon the above targets unless otherwise agreed to between the contractor and the procuring activity. (6:16)

8. MISCELLANEOUS, where the remaining ECPs are lumped together to produce a conglomerate of differing flow paths and times.

9. ENTRY-----COMPLETION, where the total average time for all ECPs, regardless of the path taken, are lumped together.

Determine the Sample Statistics. Next, QUATTRO PRO's "@AVG" and "@STDS" functions will be used to determine the sample mean and sample standard deviation for each of the groups of data. These statistics will be used to determine the LBVs of 90% one-sided confidence intervals to the numerically lower side of the sample mean. However, the values of the LBVs depend on the distribution shape of the data. Two possible distribution shapes exist for this data, normal and exponential. These two possible shapes drive the need for two different methods to determine the LBV.

Normal Distribution. When the distribution of the sample has been determined to be approximately normal, using Statistix's normality test described above, then the lower bound value of the confidence interval is determined using Equation 8 below:

$$LBV = MT - t(\alpha, v) * (S/\sqrt{n}) \tag{8}$$

where $t(\alpha, v)$ is equal to the t critical value based on the confidence factor α and the number of degrees of freedom v, where $v = n - 1$ (11:268). For a 90% one-sided confidence interval, α is equal to 0.10, so the t critical value can be read off Table A.5 in Devore's text (11:267).

Exponential Distribution. When the shape of the distribution cannot be declared approximately normal, then the adjusted K-S statistic will be computed. The researcher will calculate the K-S statistic, using MathCAD software, in accordance with the method outlined by Law and Kelton on pages 199 through 203 (20:199-203). If the adjusted K-S statistic confirms that the data is approximately exponential, then the lower bound value of the 90% one-sided confidence interval will be calculated using Equation 9 below:

$$LBV = (2 * \Sigma x_i) / y^2 \tag{9}$$

where "Σx_i" is the sum of all of the times for each process step and y^2 is the chi-squared critical value based on the number of elements in the data set and the desired confidence (11:257-258). Table A.6 from Devore's text will be used to determine the chi-squared number for sample sizes less then 20; for sample sizes greater than 20 the chi-squared critical value will be estimated (11:636).

Null and Alternate Hypotheses, FQ Number 4. The parameter of interest is μ_4, defined as the population's mean ECP processing time for each individual process flow. The null hypothesis for each flow is

$$Ho: \mu_4 \leq \mu_0 \tag{10}$$

and the alternate hypothesis is

$$\text{Ha:} \quad \mu_4 > \mu_0 \tag{11}$$

where μ_0 is the null value (the standard) of the number of days the CMP

states the process should take based on the specific process steps

included in the flow in question. The null values are repeated in

Table 6 above. The alternate hypothesis calls for an upper-tailed test

because a large test statistic value, which represents the value above

which the population mean exists, will tend to refute the null

hypothesis (11:281). Indeed, if the LBV is higher than μ_0, then the

data will indicate with 90% certainty that the population's processing

time is greater than the standard time presented in the CMP. Thus the

test statistic value that will be used to test the null hypothesis is

the value of LBV, computed from Equation 8 or Equation 9 above. And, we

accept the null hypothesis when the lower bound value of the 90% one-

sided confidence interval is less than or equal to the CMP standard

time, and we reject the null hypothesis if the LBV is higher than the

CMP standard time. If the null hypothesis is rejected, then the data

indicates that the ECP process along that flow path is taking more time

than the CMP allows, possibly because the process steps along that path

are untimely or because the ECPs in that group had to have specific

process steps accomplished more than one time.

Answer FQ Number 4. Using the calculated LBV, which

represents the lower bound above which the population means are, the

answer to the FQ for each process path can be determined. So, if the

LBV is lower than the stated CMP time for the specific process flow

path, then the answer to the FQ is "No, this specific ECP process flow

path is not necessarily taking too much time." However, if the time

stated in the CMP is less than the LBV, then the answer to the focus question is "yes, the data indicates that the ECPs that follow this process flow path on average take too much time."

FQ Number 5. Is the number of open ECPs awaiting processing in any particular process step disproportionate to the number that should be waiting in that step? This focus question attempts to determine whether or not one or more processes are untimely to the point that a disproportionate number is being processed in that step. If, for example, 95% of the open ECPs are waiting to be boarded at the CCB, but only 20% of the ECPs should be waiting processing there, then a possible problem with the SPO ECP review process will be indicated.

Assumptions for FQ Number 5. Six assumptions will be made to answer this focus question.

One. If the amount of time that each process step takes is divided by the total processing time, and if the CMP's times are used, then the expected proportionate time each step should take will be computed. Furthermore, if ECPs follow the ideal flow, and if each ECP takes the amount of time stated in the CMP to complete each process step, then the number of open ECPs should be distributed through the process steps according to the proportionate time each step should take to be completed. The major assumption here is that the open ECPs will be waiting for processing in the process steps at the same proportion as the expected proportionate amount of time that the process step should take to be completed. These expected proportions have been computed for each process step, and they are shown in Table 7 along with the number of days the process steps should take according to the CMP.

TABLE 7

EXPECTED PROPORTIONATE TIMES FOR PROCESS STEPS BASED ON CMP (9:3-2)

Step #	Step From / To	Number of Days	Proportion Percentage
	/ Submit TCP	Begin	
1.	TCP / Conduct TCM	14	$9.5 = p_1o$
2.	TCM / Submit ECP	38	$25.9 = p_2o$
3.	ECP / Conduct CCB	28	$19.0 = p_3o$
4.	CCB / GD/C Submit Response	17	$11.6 = p_4o$
5.	Response / Complete Review	40	$27.2 = p_5o$
6.	Review / On Contract	10	$6.8 = p_6o$
Total		147	100.0

Furthermore, the process steps have been named Step 1 through Step 6, and the expected proportions have been defined p1o through p6o. So if this first assumption is valid, then 27.2% of the open ECPs should be in the Contractual Review cycle. If, however, 60% of the open ECPs are actually in the contractual review cycle, then that process might be indicated as a potential problem area which may need further study to determine why the high percentage of open ECPs are awaiting completion within that process step.

Two, Three, and Four. The second assumption is that the data that will be collected are representative of the process as it has existed through July 1990, and the third assumption is that the collected data represents a random sample. Fourth, the reports from which the data will be collected are assumed to be accurate and current.

Five. The fifth assumption is that times stated in the CMP are an appropriate measurement tool with which to produce the

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expected proportionate numbers of open ECPs in each of the process steps.

Six. Since the researcher will be comparing proportions where the category probabilities are completely specified, he will use a multinomial experiment and conduct a chi-squared goodness of fit test (11:557). The experiment will consist of selecting all n open GD/C ECPs from the population of all open ECPs and categorizing each one by identifying which process step it is in, Step 1 through Step 6. This experiment will be approximately multinomial provided that n, the number of open ECPs selected, is much smaller than the population size (11:557). The researcher assumes that the number of open ECPs selected is much smaller than the population size.

Method for FQ Number 5. The FQ will be answered by comparing the actual number of ECPs in each process step to the expected number of ECPs; the expected number is equal to n multiplied by the proportions given in Table 6.

Collect the Data. The researcher will collect, on August 7, 1990 (a date that new ECP reports will be generated), information on all open GD/C ECPs. The information to be collected includes a statement that indicates which ECP process step the ECP is in. For example, if the ECP is being reviewed prior to its first presentation at the CCB, then the researcher will record, for that ECP, "Step 3," which will indicate that the ECP is somewhere in the ECP review process.

Manipulate the Data. After data on all open GD/C ECPs is collected, the researcher will sum up the number open ECPs that are

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in each of the process steps. For example, the number of ECPs in the
ECP review process will be determined; these numbers will be recorded in
a table under the heading "N_i."

Determine the Sample Statistics. Next, the chi-
squared test statistic value will be computed. This test statistic
value will be computed by adding up each step's contribution to the
overall test statistic value; these contributions are computed using
Equation 12

$$y^2_i = (N_i - np_i)^2/np_i \qquad\qquad (12)$$

where y^2_i is the step's contribution to the chi-squared test statistic
value, N_i is the actual number of open ECPs found to be waiting in the
ith process step, n is the total sample size, and np_i is the expected
number of open ECPs in each ith process step (11:560). A table will be
provided in Chapter IV which shows, for each process step, the actual
number (N_i), the expected number (np_i), the step's contribution to the
chi-squared test statistic (y^2_i), and the sum of the individual contri-
butions (labeled "Total y^2 test statistic value"). The value of y^2 will
then be compared to the chi-squared critical value, which is based on
the significance level, α, of the test and the number of degrees of
freedom, k (11:559). The significance level will be set to 0.10, and
k is equal to the number of categories minus one (11:559). Thus, for
$\alpha = 0.10$ and $k = 5$, the chi-squared critical value is 9.236 (11:636).

Null and Alternate Hypotheses, FQ Number 5. The parameters
of interest are the actual proportions of ECPs waiting processing in the
six ECP process steps. These proportions are labeled p1 through p6, and
the null hypothesis with respect to these proportions is expressed below

$$Ho: p1 - plo, \quad p2 - p2o, \quad . \quad . \quad . \quad , \quad p6 - p6o \qquad (13)$$

where plo through p6o represent the null proportion values, as shown in Table 7 above (11:559). The alternate hypothesis is expressed as

$$Ha: \text{at least one pi does not equal pio} \qquad (14)$$

where pi represents p1 through p6 and pio represents plo through p6o (11:559). The test statistic value is computed by using Equation 12 above and summing the individual step contributions to produce the chi-squared test statistic value. This test statistic value is then compared to the chi-squared critical value, which was found to be equal to 9.236 (11:636). The answer to FQ 5 will be based on whether or not the null hypothesis is rejected. The null hypothesis will be rejected if the computed chi-squared test statistic value is greater than or equal to the critical value of 9.236, which will produce an answer with significance level 0.10 (11:559,636). Armed with this information, FQ Number 5 will be able to be answered.

Answer the FQ. So, the focus question will be answered by comparing the calculated chi-squared test statistic value to the chi-squared critical value. If the test statistic value exceeds 9.236, then the null hypothesis will be rejected, and the answer to FQ 5 will be "yes, the number of open ECPs awaiting processing in at least one process step is disproportionate to the number that should be waiting in that step." However, if the test statistic value is less than 9.236, then the answer will be "no, the data does not indicate a disproportionate number of ECPs awaiting processing in any particular process step." Furthermore, regardless of the answer, this technique will indicate which process steps have the most disproportionate number of

ECPs awaiting processing by virtue of the magnitude of the individual

process step's contribution to the chi-squared test statistic value.

    <u>Summary of Efforts to Determine Timeliness</u>. This section

presented five focus questions which, when answered, are intended to

show the overall state of the ECP process, whether good or bad,

especially with regard to the process' timeliness. The five focus

questions will provide increasingly detailed evidence that will, taken

as a whole, convince the reader that the ACM SPO's ECP process is either

timely or untimely based on the assumption that the processing times

presented in the CMP are reasonable. If the result of the above

methodology shows that the process is untimely, then the assumption

about the goodness of the times presented in the CMP will need to be

validated. The goal of the methodology presented below is to validate

that assumption. If the process is found to be untimely, and if the

methodology below shows that the problem is not a too-optimistic CMP,

then the conclusion that will be made is that the ACM SPO ECP process is

untimely. Furthermore, the results of both methodologies will be used

to prepare recommended courses of action that will possibly improve the

SPO's ECP processing time.

Analyze the Survey Questionnaire Results.

    <u>Introduction</u>. The survey performed by the CPIT was intended to

provide the team with some data about their current ECP process (23).

The survey included 29 questions which the respondent was to answer by

circling a number from 1 to 6. These numbers represented responses that

the respondent could use to either agree or disagree with the specific

statement at hand. The possible responses were:

1 - This [statement] is almost always or always false
2 - This is false most of the time
3 - This is true as often as it is not true
4 - This is true most of the time
5 - This is almost always or always true
6 - This does not apply to me

This form of a Likert scale provides data which will be used to find out whether the respondents are more or less favorable to 12 specific questions; however, it cannot be used to indicate how strongly the respondents feel about the answers to the questions (13:258). The 12 questions will be selected by the researcher to test the four second-area hypothesis claims made in Chapter I, and as indicated in Figure 11. These four hypothesis claims will be converted into four focus questions, and the 12 survey question responses will tend to indicate a positive or negative response to each focus question. The hypotheses to be tested are restated below, along with the specific survey questions that will be used to answer the focus questions. Assumptions will then be presented, followed by the methodology that will be used to analyze each of the 12 survey questions. A technique will then be presented which will be used to provide an objective answer to the focus questions. Finally, a table will be presented that shows what information will be obtained by completing the steps outlined in the method portion of this section.

Develop Focus Questions. For each of the second-area Chapter I hypotheses, the focus question will be developed. The survey questions that will be analyzed to determine the answers to the focus questions will then be presented.

Communication. The first hypothesis stated in Chapter I is: ACM SPO personnel do not sufficiently communicate with other ACM program
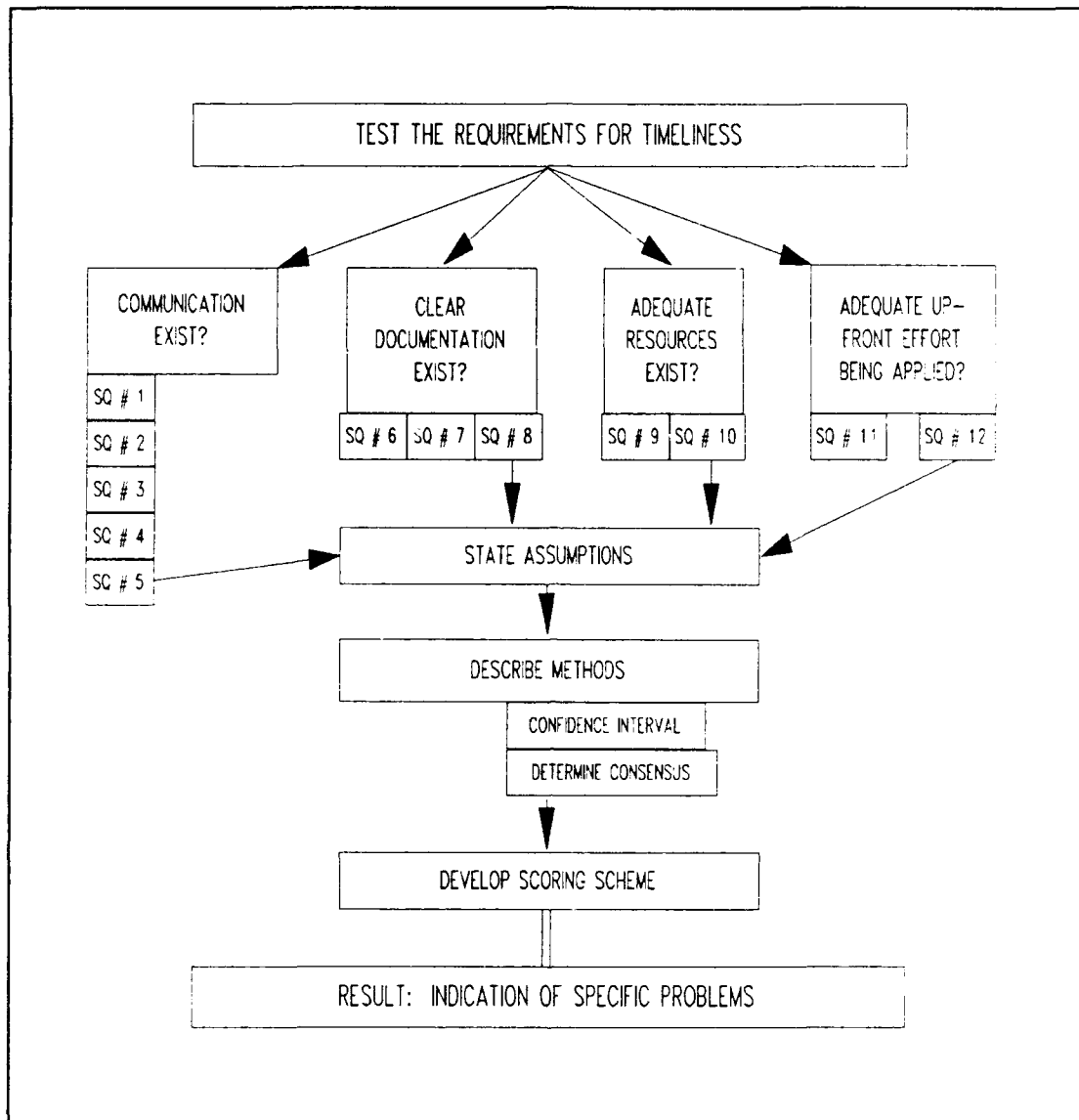
Figure 11.   Discussion Flow for Analyzing Survey Responses

personnel within or outside the SPO.   The focus question is: Does the

data indicate that people in the SPO adequately communicate with one

another and with those outside the SPO?   The CPIT's survey included five

questions regarding communication.   These five survey questions will be

analyzed to determine the answer to the focus question.

One. "I [the reviewer] go to the OPR to get my questions answered regarding an ECP/CCP [Contract Change Proposal], prior to submitting my written input." If the survey respondents circle, on average, one of the first two responses, then the survey would tend to indicate that reviewers do not ask the OPR questions before submitting their written responses and that the reviewers do not orally communicate with the OPRs.

Two. "I am informed of concessions/changes made to an ECP/CCP during negotiations that impact me." For this question, an average response of less than three will tend to support the assertion that contracts personnel do not sufficiently communicate with the other personnel involved with the ECP, especially in regards to changes in the scope of the ECP that were agreed to by the contracts personnel during the negotiation process.

Three. "I [the reviewer] give the OPR an opportunity to resolve any issues I have prior to the CCB." Here, an average response of less than three will tend to support the assertion that reviewers do not sufficiently communicate with the OPRs.

Four. "I [the OPR] am aware of all issues prior to them being raised at the CCB regarding my ECP/CCPs." For this question, an average response of less than three will tend to indicate that the reviewers do not sufficiently communicate with the OPRs before the CCB is conducted.

Five. "The CCB Representatives ask questions at the CCB that have already been resolved with their working people." / average response of more than \ ree will tend to indicate that

functional personnel do not adequately communicate with their functional representatives to the CCB.

ECP Submissions. The second hypothesis states that the contractor's ECP submissions are unclear, lack sufficient detail, and are inaccurate. The focus question is: Are the contractor's ECP submissions clear, provide the necessary detail, and accurate? The CPIT survey included three questions which, when analyzed, will tend to support a positive or negative answer to the focus question.

Six. "The Contractor has adequately addressed and documented the ECP/CCP prior to submitting it to the Government." A response of less than three will tend to indicate the contractor's ECP submissions lack sufficient detail.

Seven. "The Contractor complies with the intent of the TCM minutes." Since the TCM minutes are the final official comments to the contractor before the contractor submits the ECP, noncompliance with those minutes indicates an inability to adequately prepare the ECP. An average response of less than three will tend to indicate that the contractor's ECP submissions are inaccurate or lack sufficient detail.

Eight. "The contractor complies with the intent of the CCB Directive." If the average response of this survey question is less than three, then the indication is that the contractor's ECP submissions are unclear, lack detail, or are inaccurate.

Personnel Resources. The third hypothesis states that the ACM SPO lacks adequate personnel resources to handle the number of ECPs in the ECP process at any one time. The focus question is: Does the ACM SPO have adequate personnel resources, including the proper numbers

with proper training, to handle the number of ECPs? The survey included two questions related to personnel resources or the time the individuals had or took to work on the proposals.

Nine. "I have adequate time to review ECP/CCPs and provide comments by the date requested." An average answer less than three will tend to indicate that personnel feel as though they lack the time to adequately devote to ECPs, perhaps because their other duties take too much of their time.

Ten. "I have to go to the functionals and personally ask for their comments in order to compile them for CCB." An average answer higher than three would tend to indicate that either personnel simply do not take the time to do their work, the ECPs are not being handed to the reviewers by their organization in a timely manner, or the personnel are overloaded with other work so that they do not have the time to prepare comments in a timely manner.

Preparatory Work at TCMs. Lastly, the fourth hypothesis stated that insufficient up-front effort by government personnel at Technical Coordination Meetings (TCMs) also results in time delays. The focus question is: Do ACM SPO personnel make the effort to review the TCP before the TCM is held? The survey had two questions related to the level of effort individuals applied toward preparing for TCMs.

Eleven. "I attend the TCM for all TCPs that I would comment on as ECPs/CCPs." Any responses below three would tend to indicate that either time or schedule constraints prevent the person from attending the TCM or that the person just does not believe that it is beneficial to take the time to attend the TCM.

Twelve. "I receive comments from functionals on ECPs/CCPs who did not attend the TCM where they [the questions] could have been resolved." For this question, an average answer of more than three would indicate that the OPRs feel that personnel are not adequately reviewing the TCPs prior to the TCM.

The responses to these 12 survey questions will be analyzed by determining whether the total average responses tend to indicate either a definitely positive or a definitely negative response to the focus questions and determining whether or not general agreement exists across the SPO regarding the specific numerical response to the question. Then, a test will be presented which will provide an objective determination of whether or not the response data indicates a "yes" or a "no" answer for each of the four focus questions. Now, the researcher's assumptions will be stated.

Assumptions. Five assumptions will be stated here.

One. The first assumption is that the survey data will be able to provide an indication of ECP process problems. The survey questions were developed by the CPIT personnel to measure the perceptions that SPO personnel had about the ECP process. The survey was not necessarily prepared to minimize problems with validity. For example, the survey does not necessarily have all of the needed control questions to make sure responses are not driven by the questions (5). However, the assumption employed here is that the survey will be useful to provide an indication of ECP process problems.

Two. When determining the overall response below, one-tailed confidence intervals will be constructed about the mean responses

of the survey questions. The second assumption is that more than 30 people will respond to each question. With this being the case, the Central Limit Theorem will be invoked so that the researcher can use the z distribution to calculate the upper and lower bound values of the intervals.

Three. Another assumption is that the survey respondents are, on average, knowledgeable enough not only about the process that exists in the SPO but also about how the process should work.

Four. For determining the consensus, the sample sizes will be less than 30. However, the responses will be assumed to follow the normal distribution. This assumption will be verified by calculating Statistix's Shapiro-Francia statistic and by observing the rankits plot of the data. The assumption will be assessed by comparing this statistic to 0.90 and by visually observing an approximately linear rankits plot.

Five. The final assumption is that the answers to the survey will provide interval level data which can then be manipulated to calculate sample means and standard deviations.

Method. Eighty-six people provided responses to the survey questionnaire. For each of the 29 questions in the survey, the researcher will compile the responses and compute statistics needed to measure the SPO's perceptions about the ECP process.

Collect the Data. For each of the 86 survey responses, the researcher will enter the answers for each question into a computer spreadsheet, creating a table of data with 86 rows and 29 columns. Answers of "6" will not be included in the table because these responses

will skew the averages of the responses which are needed for the procedures below.

Manipulate the Data. Two steps are described below: determining the overall average responses to the 12 selected survey questions and determining whether a general consensus exists about the specific value of the responses.

Determine the Overall Response. To provide a picture of where the average responses fall with respect to the value of three, 90% one-tailed confidence intervals will be constructed about the 12 question's mean responses so that an assessment can be made regarding whether or not the population mean is definitely above or below the value of three, thereby indicating a definitely positive or negative response to the survey question. These intervals will have either a lower bound value (LBV) or an upper bound value (UBV), depending on the response needed to support a "no" answer to the focus question (and thereby supporting the hypothesis claim). For example, the ninth survey question, "I have adequate time to review ECPs," needs an average response of less than three (the people who answered the question need to on average feel that the answer is false) to support a no answer to the third focus question which asks, "Does the SPO have adequate personnel resources?" The researcher is looking for an average response of less than three, so the researcher will calculate an UBV below which the population response lies, with 90% confidence. On the other hand, the tenth survey question, "I have to go to the functionals to get responses," requires an average response of greater than three to support a no answer to the third focus question. In this case, a LBV

will be calculated above which the population response lies, with 90%

assurance. Since the sample size is assumed to be greater than 30,

Equations 15 and 16 below use the z distribution to calculate the LBV

and the UBV

$$LBV = MR - Z\alpha * (S/\sqrt{n}) \tag{15}$$

$$UBV = MR + Z\alpha * (S/\sqrt{n}) \tag{16}$$

where MR is the mean response, $Z\alpha = 1.282$, and n is the sample size

(11:634). Thus, if the LBV is above the value of three, or if the UBV

is below the value of three, then support for the hypothesis claim, from

which the focus question was derived, will be indicated. These bound

values will be computed and bar charts will be constructed to show where

the data indicates that the true average response lies. If the total

confidence interval is to one side or the other of the value of three,

then the researcher will claim that the data tends to support a

definitely positive or negative response to the focus question. A

statement will be made regarding whether or not the answer to the focus

question tends to support the claim. In summary, the parameter of

interest is the population mean response to each of the survey questions

selected by the researcher to test the major hypothesis claims. The

null hypothesis is that the population mean is equal to the value of

three, as indicated in Equation 17 below. The alternate hypothesis will

be constructed one of two possible ways, as Equation 18 and Equation 19

indicate.

$$Ho: \mu_R = 3 \tag{17}$$

$$Ha: \mu_R > 3, \text{ need a LBV} \tag{18}$$

$$Ha: \mu_R < 3, \text{ need a UBV} \tag{19}$$

where μ_R is the parameter of interest defined as the population mean

response to the survey question, "need a LBV" implies that the

population response needs to be greater than three to indicate a "no"

response to the focus question, and "need a UBV" implies that the

population response needs to be less than three to indicate a "no"

response to the focus question. The test will be conducted by

calculating the appropriate bound value and seeing whether or not the

LBV is greater than 3 or the UBV is less than 3. If yes, then the null

hypothesis will be rejected in favor of the alternate hypothesis, the

focus question will be answered "no," and support for the major

hypothesis claim will be indicated. The next step is to see if positive

consensus exists about the average numerical response.

Determine Consensus. By following the method above,

confidence intervals will indicate where the population means for the

responses lie with respect to the value of three. These confidence

intervals will provide one piece of information for each survey

question. The sample mean will provide a second piece of information.

However, the researcher needs more information so that a point-measuring

scheme can be used to evaluate the net effect of the responses to the

survey questions on the answers to the four focus questions. One

additional piece of information that would be useful for this effort is

a determination of whether or not the response to the question is

consistent regardless of the general attitudes of the people responding

to the question. In other words, if people who exhibit an overall

favorable attitude tend to answer a question negatively, and if the

people who exhibit an overall unfavorable attitude also tend to answer

that question negatively, then consensus about that question will be assumed to exist (13:256). To determine whether or not consensus exists for each survey question, Each respondent's total average score will be computed using QUATTRO PRO's @AVG function. These averages will be sorted from lowest to highest using QUATTRO PRO's sorting capability. Thus the respondents having the lowest average scores will be at the top of the list and the respondents with the highest average scores will be at the bottom of the list. Next, the top 28 sets of responses on the sorted list (the "Low Group," named because their average responses were relatively numerically lower) and the bottom 28 sets of responses (the "High Group") of the list will be selected. The two group's average responses for each question will be computed so that the two extreme groups' responses can be compared to determine whether or not agreement exists, among those who responded, about the responses to the specific questions (13:256). Next, for each of the 12 individual questions selected by the researcher, the two group's means, sample standard deviations, and the numbers of people in that group who responded to that particular question will be computed (13:257). The group means for these 12 questions will then be tested with a pooled two-sample t test to determine whether or not the groups' mean responses are the same. If the data indicates that the mean responses are the same, then consensus will be said to exist. This technique will allow the researcher to determine whether or not the two groups have the same attitude concerning the specific question (13:256). The pooled two-sample t test will be conducted by calculating the test statistic value using Equation 20 below and comparing that value to the t critical value which

is based on the significance level and the number of degrees of freedom (a function of the number who responded to the question) (11:336). The significance level will be set to 0.10, and the t critical value will be read off of Table A.5 in Devore's text (11:635). Equation 20, obtained from page 336 in Devore's text, is:

$$t = (MHG - MLG)/(Sp * \sqrt{(1/m + 1/n)}) \qquad (20)$$

where t is the test statistic value, MHG is the mean response from the High Group, MLG is the Low Group's mean response, Sp is the pooled sample standard deviation, m is the High Group's sample size, and n is the Low Group's sample size (11:336). The pooled sample standard deviation is determined using Equation 21 (11:335).

$$Sp^2 = \{(m-1)*SHG^2 + (n-1)*SLG^2\} / (m+n-2) \qquad (21)$$

where SHG is the High Group's sample standard deviation and SLG is the Low Group's sample standard deviation. For each question, a table will be provided which shows whether or not the null hypothesis was accepted or rejected, where the null and alternate hypotheses are

$$Ho: MHG = MLG \qquad (22)$$

$$Ha: MHG =/= MLG. \qquad (23)$$

So, if the absolute value of the test statistic value is lower than the t critical value, then the null hypothesis will be accepted, supporting the assertion that general agreement exists about the numerical value of the average response (11:336).

Summary Table of Collected Information. The methodology described above will produce the information described here. For each of the survey questions that will be used to answer the four focus questions, the needed response to indicate support for the hypothesis claim

TABLE 8

SUMMARY OF INFORMATION TO BE OBTAINED FROM METHODOLOGY

	MR Needed to Support Claim	Means LGM/HGM/Tot	Consensus?	Response Definite?
Focus Question I				
SQ 1	MR < 3	Values	Yes	Yes
SQ 2	MR < 3		or	or
SQ 3	MR < 3		No	No
SQ 4	MR < 3			
SQ 5	MR > 3			
Focus Question II				
SQ 6	MR < 3			
SQ 7	MR < 3			
SQ 8	MR < 3			
Focus Question III				
SQ 9	MR < 3			
SQ 10	MR > 3			
Focus Question IV				
SQ 11	MR < 3			
SQ 12	MR > 3			

is listed. Other data to be collected includes the value of the average response, an indication of whether or not the population mean response is to the "correct" side of the value of three (thereby supporting a "no" answer to the focus question), the values of the High Group and Low Group means, and an indication of whether or not the both groups felt similarly about the answer to the question. This information will be collected and provided in a table identical to the one shown in Table 8. Moreover, a bar chart will be prepared to show not only the two groups'

(the Low Group and the High Group) responses but also the mean response of the total data set. Another bar chart will be prepared that shows the results of computing the confidence interval about the total data set means for each question. This chart will have bars with shaded regions which represent the interval within which the true mean is located, with 90% confidence. If the interval does not cross the value of three, then the researcher will make a definite statement about what the data indicates, especially in light of the other reported information.

Evaluating the Major Hypotheses. Unfortunately, the method presented thus far does not lend itself to objective conclusions regarding the major hypotheses presented in Chapter I. For example, recall that five survey questions were selected to test the hypothesis that poor communication in the SPO was causing untimely ECP processing. Do we make all five survey responses point decisively to communication as a problem before we assert that the hypothesis claim is supported? Indeed, this requirement seems to be impractical. Well then, how many of the survey responses must indicate communication as a problem before the hypothesis claim will be supported? This section describes a technique which will be used to objectively evaluate whether or not the survey responses support the hypothesis claims. First, the information available for determining an objective answer to the focus question for each hypothesis will be listed. Then, the evaluation technique will be presented and explained. Finally, a table will be developed which will be filled in with Chapter IV results to determine what the answer is to

each of the four focus questions. These answers will be used to indicate support for the four major hypotheses.

The Available Information. The method described thus far will provide the following information: 1) what value should the mean response be to indicate a "no" answer to the focus question being considered, 2) the sample mean of each of the 12 survey responses, 3) the value of the Low Group's mean, 4) the value of the High Group's mean, 5) a confidence interval about the mean response which will show whether or not the population mean is definitely to the "correct" side of the value of three, and 6) an indication of whether or not the two High and Low Group means are equivalent. This information will be used to develop an objective test that will be used to determine whether or not the survey responses support the hypothesis claims.

Evaluation Technique. The researcher will assess a "value" to data items 2 through 6 above if those data items indicate support for the hypothesis claim. The values will be awarded if the average or the interval is on the side of the value of three needed to support the hypothesis claim. For example, for the first focus question, the response of Survey Question Number 1 needs to be less than three to indicate a "no" response to the focus question. So, if the average response is less than three, then the survey question will be awarded a score. Likewise, if both group means are below the value of three, then the survey question will be awarded a higher score. The point values will be assessed as follows:

    0.15 points if the mean response indicates a "no" answer to the FQ
    0.10 points if the Low Group's mean indicates a "no"
    0.15 points if the High Group's mean indicates a "no"

0.45 points if the entire interval about the mean indicates a "no"
0.15 points if both group means support the mean and are
determined to be equivalent

Thus, the maximum score that each survey question may be awarded is 1.0 points. The points will be awarded to each survey question. Then the points will be summed for each focus question. The sum will be divided by the number of survey questions being used to answer the focus question so that a ratio will be calculated. If the ratio is greater than or equal to 0.6, then the overall answer to the focus question will be determined to be "no," thereby indicating support for the hypothesis claim from which the focus question was generated. So, we now have an objective test that can be used to determine whether the survey questions tend to support the hypothesis claims.

Table. Table 9 shows, for each major hypothesis and for each survey question, how the net results of the computations in this section will be recorded. The values awarded to the survey questions will be included on the table, and they will be summed. Each major hypothesis' ratio will be computed by dividing the sum of the survey question total scores by the number of survey questions used to test the hypothesis. If the ratio is greater than 0.6, then the hypothesis claim will be accepted. If the ratio is less than or equal to 0.6, then the hypothesis claim will be rejected.

Chapter Summary

In summary, this chapter provides the methodology for determining not only whether or not the ECP process is untimely with respect to the time guidelines provided in the CMP, but also whether, in a general sense, the SPO personnel involved with the process believe that those

TABLE 9

THE END RESULTS CF THE TESTS OF THE HYPOTHESES

	MR Needed to Support Claim	MR	Points Awarded For LGM	HGM	Intvl	Iden	Max Score
Survey Question 1	MR < 3	Values Up to					
Survey Question 2	MR < 3	0.15	0.10	0.15	0.45	0.15	1.00
Survey Question 3	MR < 3						
Survey Question 4	MR < 3						
Survey Question 5	MR > 3						
Hypothesis I Ratio: (Sum of SQs 1 - 5) / 5 =							1.00
Survey Question 6	MR < 3						
Survey Question 7	MR < 3						
Survey Question 8	MR < 3						
Hypothesis II Ratio: (Sum of SQs 6 - 8) / 3 =							1.00
Survey Question 9	MR < 3						
Survey Question 10	MR > 3						
Hypothesis III Ratio: (Sum of SQs 9 & 10) / 2 =							1.00
Survey Question 11	MR < 3						
Survey Question 12	MR > 3						
Hypothesis IV Ratio: (Sum of SQs 11 & 12) / 2 =							1.00

CMP times are reasonable and that problems with the process itself are driving the timeliness problem. Chapter IV will provide the results and summaries of the findings obtained from performing the steps in this chapter, and Chapter V will present a summary of the thesis effort, the conclusions, and the recommendations.

IV. Results and Findings

Chapter III presented a "cookbook" of steps to be performed and it stated that the results would be presented in Chapter IV. Thus it is in this chapter that the reader will begin to see whether or not the ACM SPO ECP process is untimely, with respect to the times stated within the CMP, and whether or not the hypotheses, presented in Chapter I, are valid claims. First, the results of the study of ACM SPO ECP process' timeliness will be presented. Then, the results from the analysis of the survey questionnaires will be summarized and statements regarding the hypothesis claims will be made.

Timeliness of ECP Process

In this section, the results of the data analysis that was used to answer the five focus questions will be presented.

FQ Number 1. Is the ACM SPO ECP process taking too much time? Forty-three ECPs met the criteria for selection.

Results. The average number of days the ECPs took to be processed was 220.2 days with a sample standard deviation of 80.6 days. The LBV was calculated, and Figure 12 shows the results. The left vertical bar indicates the CMP standard of 147 days. The right bar shows where the sample mean and LBV fell with respect to the standard; namely, the LBV is greater than the standard value of 147 days.

Findings. Since the LBV is greater than the CMP standard, the answer to the focus question is "yes, the process is indicated as untimely." With this answer, attempts to answer the next four focus

FOCUS QUESTION NUMBER 1
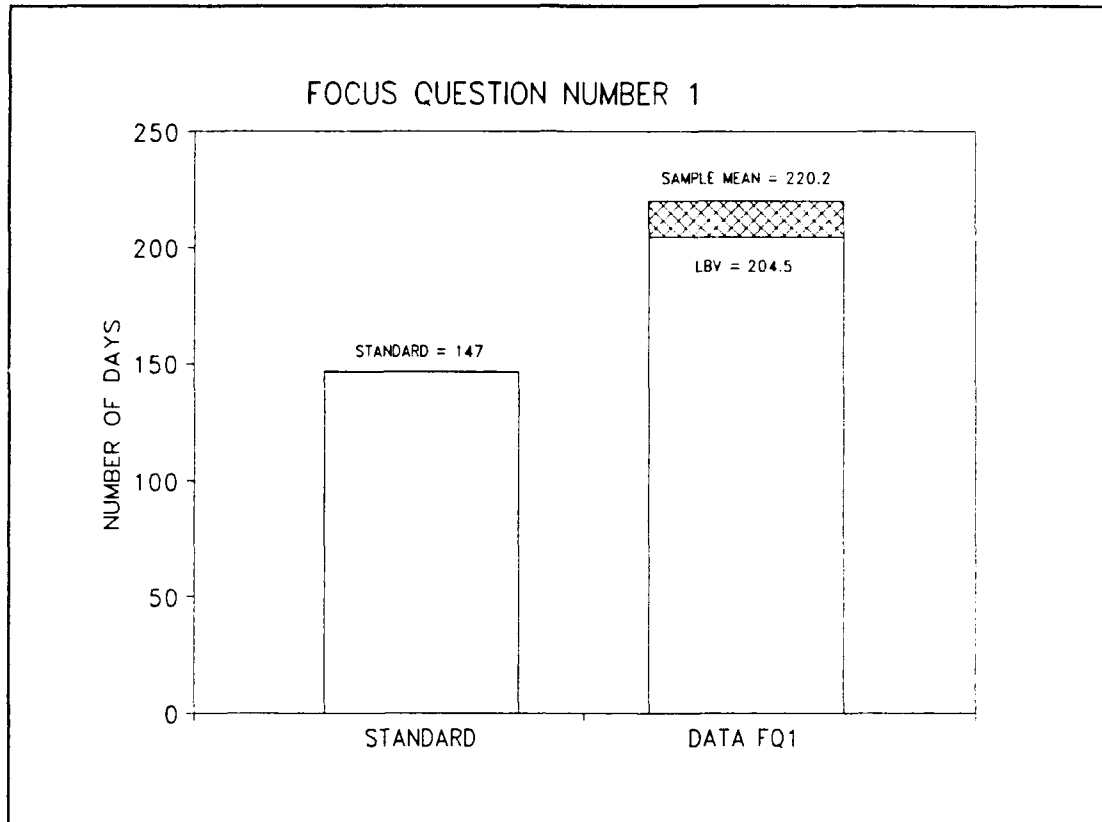
Figure 12. Results for Focus Question Number 1

questions may pinpoint which specific areas of the ECP process are

having the most difficulty with timeliness.

FQ Number 2. Are individual process steps taking too much time?

Results. Table 10 below provides a summary of the results

collected by performing the methodology for FQ Number 2. For each

different process step, the table provides the following information:

the identified shape of the distribution (for sample sizes greater than

30, "CLT" is listed to signify the use of the Central Limit Theorem),

the number of ECPs that travelled through that particular step, the

average number of days each ECP took to be processed within that step,

the sample's standard deviation, the LBV, and the goal provided by the

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TABLE 10

RESULTS OF SPREADSHEET MANIPULATION

Step From / To	Shape	# of Occur- rences	Sample Mean	Sample Std Dev'n	LBV	Goal (CMP)
TCP 1 - ECP 1	E	5	40.6	21.8	25.4	52
TCP 1 - TCM 1	CLT	49	23.1	13.8	20.6	14
TCM 1 - ECP 1	CLT	45	70.2	48.4	61.9	38
TCM 1 - TCP 2	E	4	47.7	25.7	28.6	
TCP 2 - TCM 2	E	5	27.0	29.7	16.9	
TCM 2 - ECP 1	E	5	51.2	39.4	32.0	
ECP 1 - CCB 1	CLT	60	30.2	27.7	25.6	28
CCB 1 - ECP 2	CLT	47	37.2	33.5	30.9	17
CCB 1 - REV	E	5	54.8	47.8	34.3	57
CCB 1 - COM OUT	N	8	33.5	25.8	20.6	7
ECP 2 - OPR 1	CLT	39	19.6	17.4	16.0	
ECP 2 - CCB 2	N	8	12.6	9.2	8.0	
CCB 2 - ECP 3	E	7	22.4	20.2	14.9	
ECP 3 - OPR 1	N	5	2.4	2.6	0.6	
OPR 1 - REV	CLT	34	38.6	32.5	31.4	
OPR 1 - OPR 2	N	10	51.2	35.5	35.7	
OPR 2 - REV	N	10	33.8	31.8	19.9	
REV - S/A	CLT	51	9.4	16.8	6.4	101

CMP. No times are listed under the "Goal" column when the CMP does not address a time requirement. For those process steps that had more than 10 occurrences, Figure 13 provides a pictorial view of the relationship between the CMP stated times, when those times are provided in the CMP, and the lower bound values. The CMP times are indicated by virtue of the height of the thinner and more darkly shaded bars adjoining the left edges of the data bars. By simply looking at Figure 13, and by studying Table 10, one can determine which process steps are indicated as possibly being untimely by comparing the LBV, represented by the lower edge of the shaded region of the data bars, to the stated amount of time

MOST FREQUENTLY ACCESSED STEPS
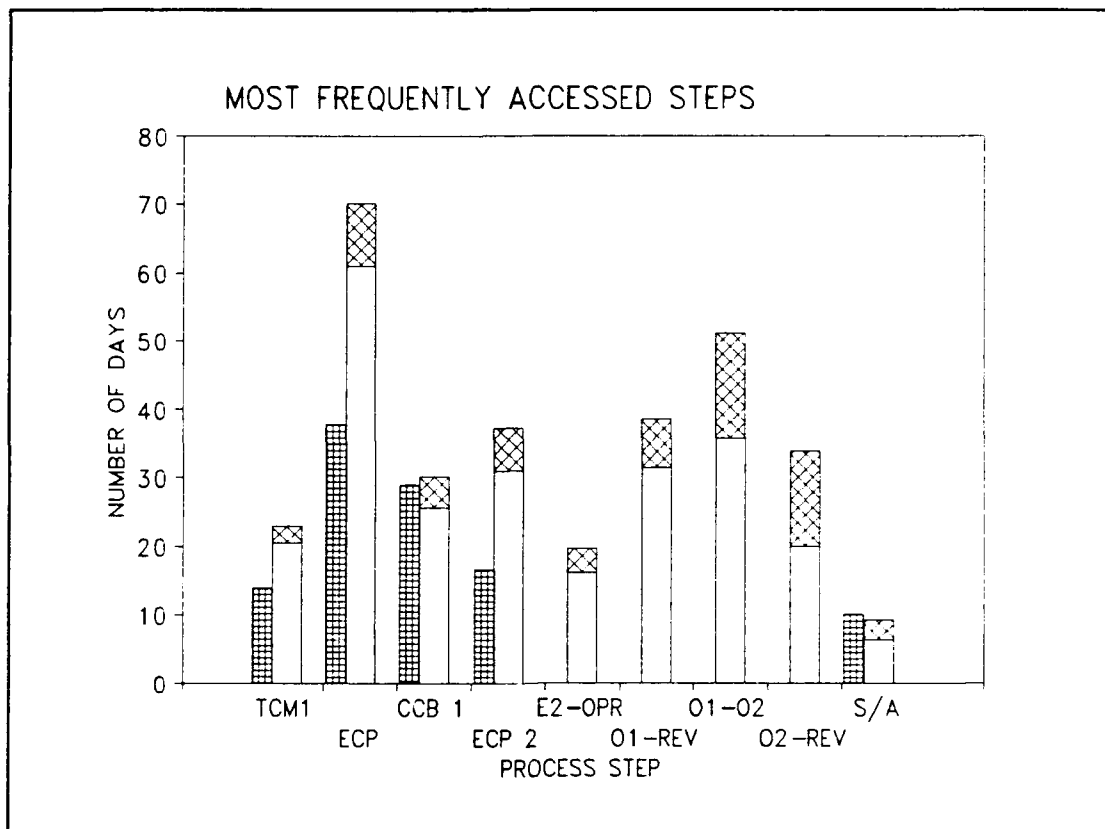
Figure 13.   Results from FQ Number 2 Data Analysis

the process should take.   These potentially untimely steps are listed

below.

TCP Receipt-TCM:	LBV = 20.5 days versus CMP goal of 14 days
TCM-ECP Receipt:	LBV = 61.0 " " " " " 38 "
CCB-GD/C Response:	LBV = 31.2 "	17
Resp-Rev Complete:	LBV = 16.1+32.5	40
OPR-OPR-Rev Complete:	MTs = 51.2+33.8	0

Some process steps were indicated as possibly being more timely than the

times presented in the CMP.   For example, ECPs that were approved at the

CCB were allowed 57 days to have all contractual review steps completed.

However, these ECPs took on average less than 55 days, and the

population mean could be as low as only 35 days.   Also, the ECP review

step had a lower bound value of 25.6 days, which is less than the CMP

goal of 28 days, and the supplemental agreement step took on average 9.4 days, less than the goal of 10 days. The process steps for which the CMP did not provide times proved to add significant time to the total process. For example, it took approximately 126 days on average to process ECPs through the second TCM, when a second TCM was required. It took another 51.2 days, on average, to process ECPs through a second OPR Approval step.

Findings. The findings here are that certain process steps appear to be more untimely than others. While the ACM SPO seems to be doing a fair job of boarding an ECP at the CCB within the time outlined in the CMP, it is taking approximately one week too long to conduct a TCM and about two weeks longer than it should take to submit CCBDs to the contractor when ECPs are disapproved (the CCB 1 - COMments OUT step). Furthermore, the time it took for the SPO to receive the ECP after the TCM was conducted was, on average, 70.2 days. The CMP provides only 38 days for this step. The initial tendency is to perhaps blame the contractor. However, within the 70 days, the contractor has been preparing TCM minutes that the SPO has to approve before the contractor can begin preparing the ECP. Also, for proposals that are originally submitted with a cost volume, the contractor must take time to prepare the cost volume after the TCM. So, further research is needed in this area to determine where the bulk of the time delay is and to determine if the CMP perhaps does not provide enough time to perform this process step.

FQ Number 3. Are the ACM SPO ECPs being routed through the same process steps more times than once?

Results. The results of the data gathering effort are indicated in Figure 14 and Figure 15. Sixty proposals had activity during the seven month period and were subsequently closed by August 7, 1990. Figure 14 shows the routes, and the number of times the route was accessed, from TCP receipt to the CCB. Five proposals entered the
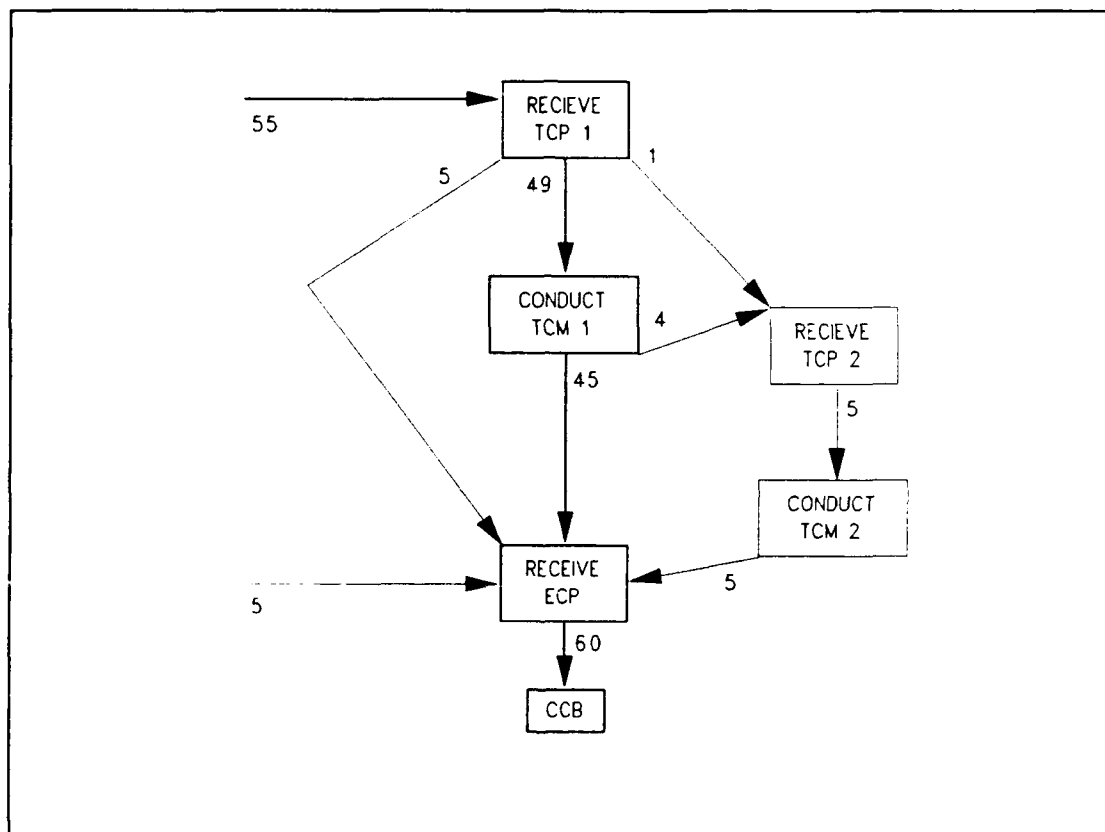
Figure 14. Process Flows from TCP to CCB

system without TCPs or TCM, while the remaining 55 entered the system in the form of a TCP. All 60 made it to a CCB, but five proposed changes required an updated TCP before the ECP was submitted. The bold lines and boxes indicate, for Figure 14, not only the ideal flow but also the flow most frequently used by these 60 ECPs. In fact, 45 of the 60 ECPs,

or 75%, followed the ideal flow up to the CCB. However, this percentage

drops dramatically for the steps beyond the CCB, as Figure 15 indicates.

To refresh the reader's memory, the ideal flow would include approval of
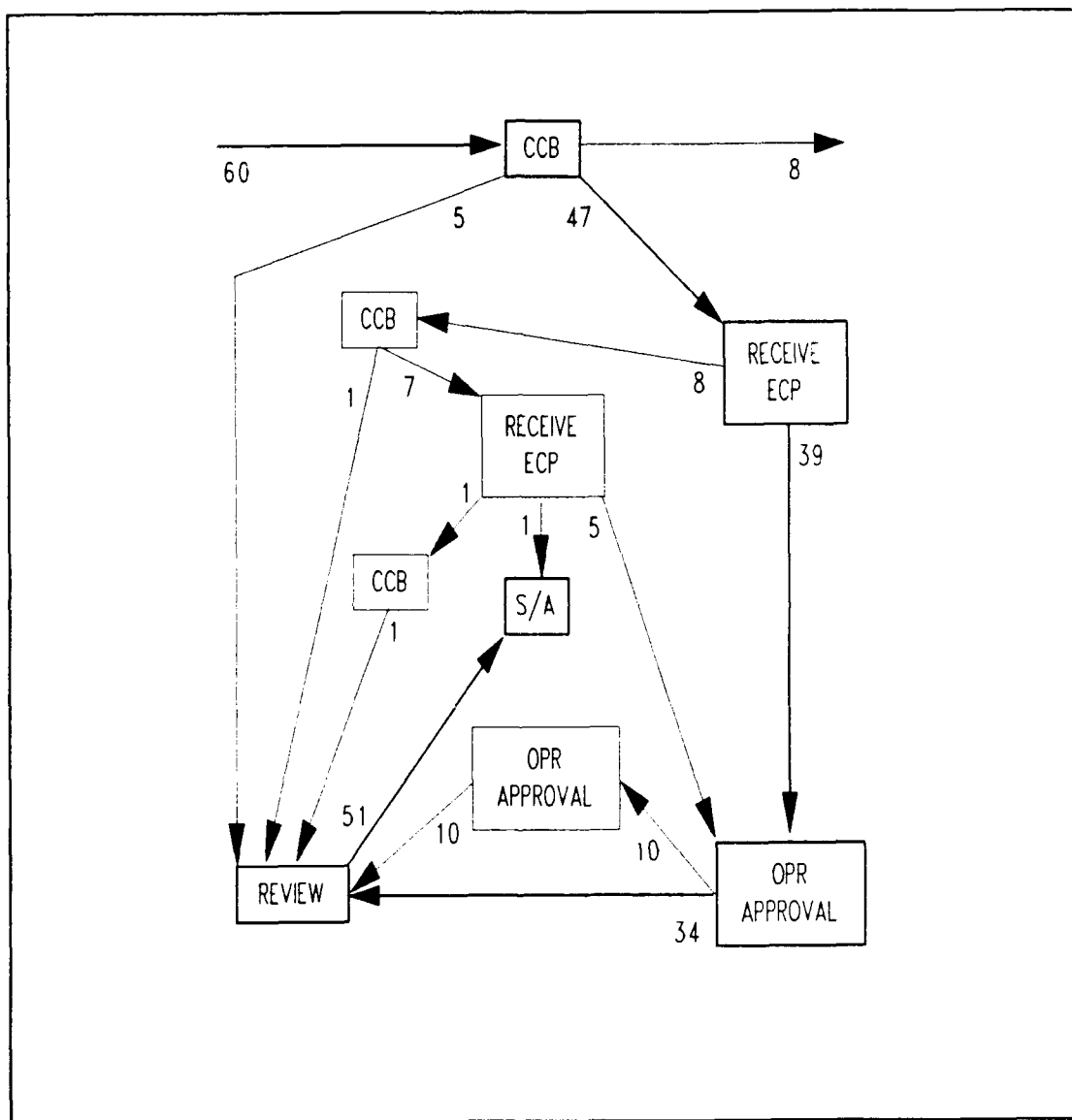
Figure 15. Process Flows from CCB to S/A

the ECP at the CCB followed immediately by the review process and

supplemental agreement. However, the most frequent disposition of the

ECPs at the CCB was "approved with comment," which meant that these ECPs needed to be updated with the CCB comments before they could be approved and before the review process could begin. The frequency of ECPs getting approved with comments was 47 times out of 60, or roughly 78%, while the frequency at which the ECPs were approved as written, the ideal disposition, was only five times out of the 60, or about 8%. In other words, the proportion of ECPs that are Approved with Comments, defined as pa in Chapter III, is 0.78. This proportion is much higher than that of 0.30 which was proposed by the researcher as the test to determine whether process steps were having to be re-accomplished. Furthermore, of the ECPs that were eventually approved, 47 of 52, or 90.4%, had to have processing steps re-accomplished. The other test provided in Chapter III was to compare the percentage of the number of ECPs that did not get approved by the OPR at the first OPR Approval decision point to the value of 0.20. Figure 15 shows that of 44 proposals arriving at the first OPR Approval decision point, 10 of them, or 22.7%, were not approved by the OPR. Other information can be pulled from Figure 15 also. For example, eight of the 47, or 17%, of the ECPs that were boarded at the ECP required changes sufficient enough that the ECP had to be brought back to the CCB for approval. Furthermore, of those eight ECPs, seven required even further updates before they could be approved.

Findings. The major finding is that the ECPs are having to have process steps re-accomplished. This may be necessary because of inadequate communication between the SPO and the contractor, inadequate TCP review and TCM process steps on the part of the SPO, or an inability

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on the part of the contractor to follow the directions outlined in the TCM minutes or in the CCBD. The analysis of the survey will possibly reveal one or more of these potential problems as the reason why ECPs do not follow the ideal process flow, but instead must be processed through certain steps more than once.

FQ Number 4. Are there any specific ECP process flow paths that are more timely than the CMP requirements?

Results. Recall that Table 6 in Chapter III (see page 84) presented a list of the nine different process flow times and the number of days the CMP stated that the flows should take. The Table 6 data is presented here in Table 11, which provides not only the Table 6 information but also the actual flow averages and LBVs. Figure 16 presents the

TABLE 11

PROCESS FLOW PATHS, CMP TIMES, AND ACTUALS (9:3-2)

Path Number and Process Flow	Days CMP	Avg Days	LBV
1. TCP-TCM-ECP-CCB-ECP-OPR-REV-S/A	147	233.1	209.5
2. TCP-TCM-ECP-CCB-ECP-OPR-OPR-REV-S/A	147	251.0	209.8
3. TCP-ECP-CCB-ECP-OPR-REV-S/A	147	252.8	241.2
4. TCP-TCM-ECP-CCB-REV-S/A	147	107.2	90.1
5. TCP-TCM-ECP-CCB-COMM OUT	97	183.8	148.5
6. TCP-TCM-TCP-TCM-ECP-CCB---COMPLETION	147	238.5	205.1
7. ECP-CCB---S/A	95	159.7	53.8
8. MISCELLANEOUS	126	205.7	193.8
9. ENTRY-----COMPLETION	138	215.9	209.2

Note: time allowances assume the ECP is a no-cost change.

same information in the form of a bar chart. The heights of the more darkly shaded and thinner bars, called "standard" bars, provide a

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NUMBER OF DAYS FOR PROCESS FLOW PATHS
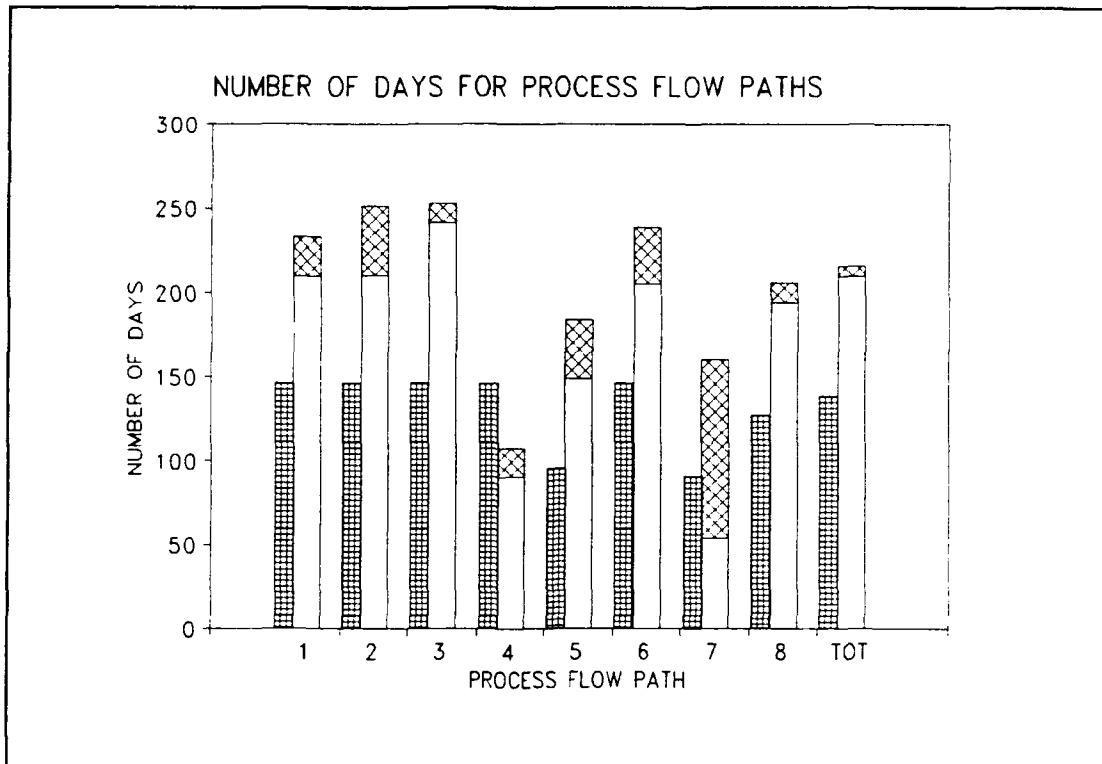
Figure 16.   Average Path Flow Times

picture of how much time is provided for each path in the CMP, and were

determined based on the CMP time allowances for completing the major

process steps in the flow path.   For example, Path 8's and Path 9's

standard bars' heights were calculated by averaging the time allowed for

each ECP based on each ECP's path flow.   The bottom edge of the shaded

region on the data bars indicates the lower bound value.   Thus, by

comparing the tops of the standard bars to the bottoms of the shaded

regions on the data bars, one can see whether or not the process flow

path provided approved ECPs faster than the time requirements spelled

out in the CMP.   Only two paths potentially qualify for this

distinction, Path 4 and Path 7.   Path 7 ECPs did not go through the TCP

Review and TCM process steps because a TCP was never submitted.   On the

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surface, one could say that ECP process timeliness will improve by eliminating these steps; however, only three ECPs are included in this sample, and the variation in processing time between them was relatively high, explaining why the interval between the sample mean and the lower bound value appears to be so large. Furthermore, the average of the three Path 7 ECPs was almost 160 days, 168% more than that allowed in the CMP. The other potentially timely path is Path 4. This path is the ideal path flow for ECPs to follow, and, since it is indicated as potentially timely, provides some evidence that if the process steps are done correctly the first time, a timely process can result.

Findings. ECPs that follow Path 4 and Path 7 were timely enough to allow them to be candidates for timely ECP path flows. Of the two, Path 7 appears to qualify for the distinction only because the small sample size and the relatively wide variation in the data forced the lower bound value to be below the time requirement. Path 4, on the other hand, had a relatively small variation in the data, plus the sample mean was relatively far below the time requirement. The finding here is that yes, one process flow path appears to be more timely than the CMP requirement; indeed, that path was the only path that did not have ECPs re-accomplishing process steps. Thus, a correlation seems to exist between timeliness and "doing things correct the first time," and the indication is that the ACM SPO ECP process may be able to become a timely process if efforts are taken to reduce the frequency of re-accomplishing process steps.

FQ Number 5. Is the number of open ECPs awaiting processing in any particular process step disproportionate to the number that should be waiting in that step?

Results. Sixty-four ECPs were open on August 3, 1990. Table 12 below shows, for each of the six process steps, the expected number of ECPs in each step, the actual number in the step, the step's

TABLE 12

COMPUTATIONS AND RESULTS OF TEST OF PROPORTIONS

Waiting for	Actual Count N_i	Expected Percent p_i	Expected Number np_i	Contribn to $y2_i$
TCM Approval	5	9.5	6.08	0.192
ECP # 1	10	25.9	16.58	2.611
CCB # 1	12	19.0	12.16	0.002
GD/C RESP	7	11.6	7.42	0.024
Review	27	27.2	17.41	5.282
S/A	3	6.8	4.35	0.419
Total	64	100.0	64.00	

Total Computed y^2 Test Statistic Value   8.530

The y^2 Critical Value (11:636)   9.236

Note: 20 of the 27 waiting for Review are actually waiting for OPR Approval

contribution to the chi-squared test statistic, and the total chi-squared test statistic value. By comparing the calculated test statistic value to the chi-squared critical value, it is apparent that the data does not indicate a disproportionate distribution of the ECPs in the process steps. The largest contribution to the calculated test

statistic value was from the Contractual Review process step. An anomaly of the data is that 20 of the 27 ECPs in that category were actually waiting for the OPR to approve the contractor's latest ECP submission.

Findings. The null hypothesis, which stated that the actual proportions equal the expected proportions, could not be rejected. The data does not indicate a problem with the distribution of open ECPs in the ECP process steps. However, the fact that 20 of 27 ECPs recorded in the contractual review category were waiting for OPR approval indicates a potential problem. Perhaps OPRs are being overworked and are unable to devote time to these ECPs that require their attention. Perhaps too the ECP reports from which the data was taken were not updated. In any case, the incident is cause for some concern and perhaps some additional study.

Summary of Results to Determine Process Timeliness. Briefly, in this section five focus questions were answered. Four of the focus questions were answered with a "yes," tending to indicate support for the claim that the ECP process is not timely, at least with respect to the CMP's stated times. Next, we attempt to determine whether the process is untimely or if the CMP's processing times are unrealistic.

Analyze the Survey Questionnaire Results

General Results. Table 13 below presents the results of the data analysis, spelling out the survey question number, the value (MR) of the mean response needed to support the hypothesis claim (whether less than or more than the value of three), the Low Group, High Group, and Total mean responses, whether or not the Low and High Group means are

TABLE 13

INFORMATION OBTAINED FROM METHODOLOGY

	MR Needed to Support Claim	Means LGM/HGM/Tot	Consensus?	Response Definite?
Focus Question I				
SQ 1	MR < 3	3.28/ 3.78/ 3.51	Yes	No UBV=3.69
SQ 2	MR < 3	1.88/ 3.46/ 2.66	No	Yes UBV=2.85
SQ 3	MR <	3.67/ 4.57/ 4.01	No	No UBV=4.15
SQ 4	MR < 3	3.11/ 4.50/ 3.55	No	No UBV=3.82
SQ 5	MR 3	3.22/ 3.63/ 3.36	Yes	Yes LBV=3.13
Focus Question II				
SQ 6	MR < 3	2.18/ 3.25/ 2.72	No	Yes UBV=2.86
SQ 7	MR < 3	2.94/ 4.08/ 3.46	No	No UBV=3.60
SQ 8	MR < 3	3.82/ 4.28/ 3.53	No	No UBV=3.69
Focus Question III				
SQ 9	MR < 3	2.85/ 4.04/ 3.33	No	No UBV=3.47
SQ 10	MR > 3	3.50/ 3.88/ 3.60	Yes	Yes LBV=3.37
Focus Question IV				
SQ 11	MR < 3	2.52/ 3.00/ 2.77	Yes	Yes UBV=2.99
SQ 12	MR > 3	3.22/ 3.86/ 3.38	Yes	Yes LBV=3.17

statistically close (consensus`, and whether or not the 90% confidence
interval about the total mean indicates a definite response that
supports the hypothesis claim (the yes or no answer is provided along
with the value of either the upper bound value or the lower bound
value). As a note of explanation, if the answer to "Consensus" is yes,
then that means that the High Group and the Low Group means are
statistically close. It does not mean that the data indicates support
for the hypothesis claim. The consensus information is provided so that

the reader may understand which questions produced the same general feeling in the people throughout those that answered the survey. Figure 17 provides a visualization of the consensus in the SPO about the twelve different survey questions. It shows the Low Group's mean, the mean of all of the responses, and the High Group's mean, and it shows the relative variation between the two group's mean responses. For

AVERAGE RESPONSES
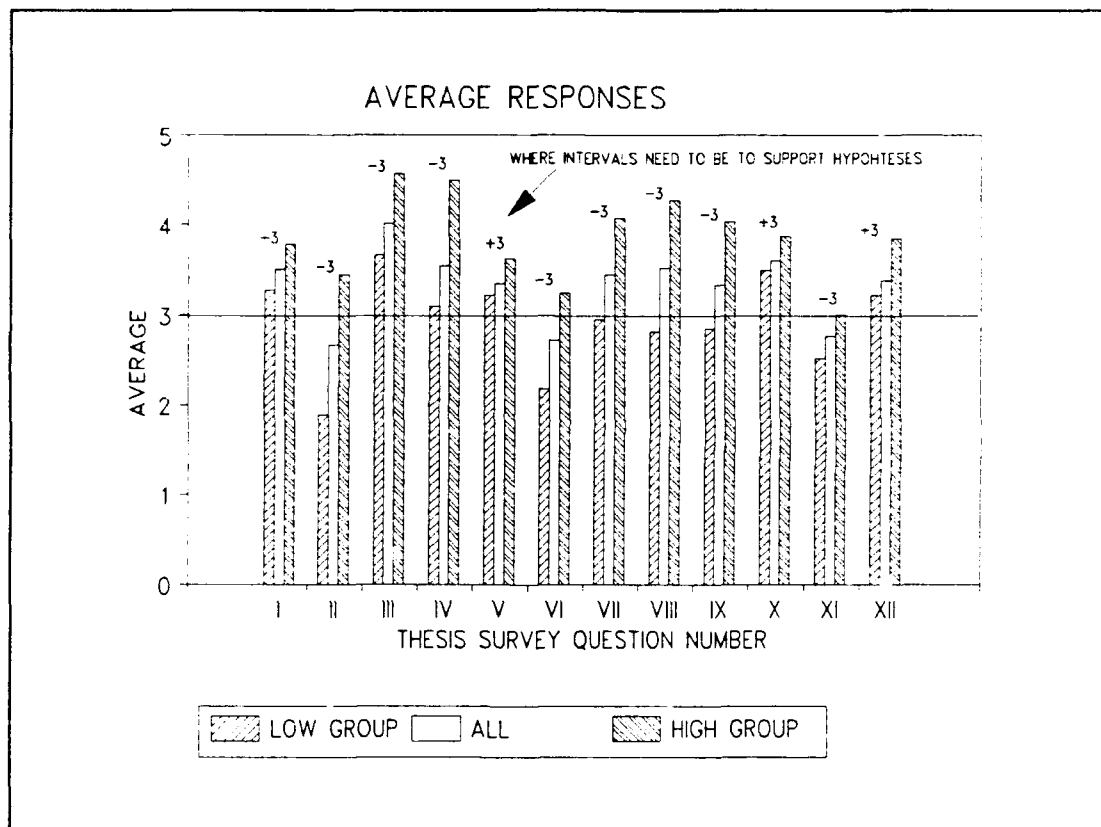
Figure 17. A Picture of Consensus

example, Survey Question Number 6 produced a marked difference in group mean scores, while Survey Question Number 12 produced fairly consistent mean responses. Figure 18, on the other hand, shows whether or not the population mean lies to the "correct" side of the value of three to

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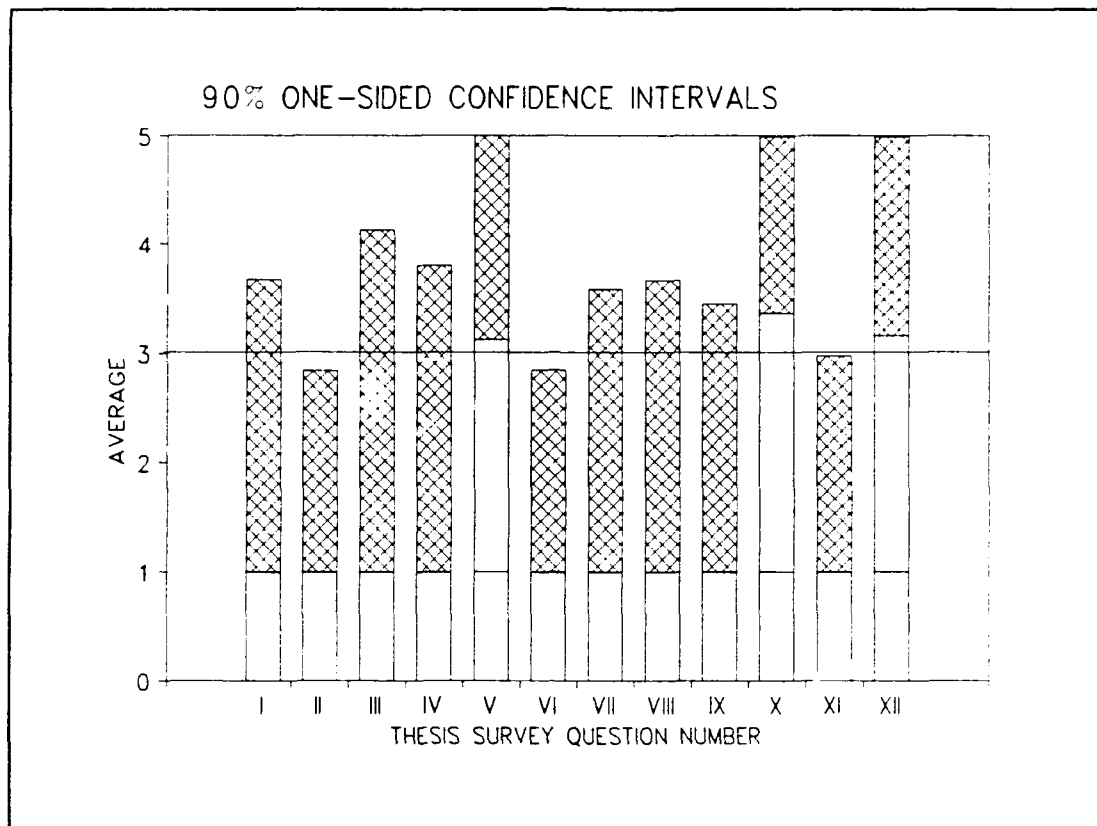
Figure 18.   90% Confidence Intervals About the Means

support the hypothesis claims. For Survey Question Number 2, the shaded

region represents the entire interval within which the population mean

response lies, with 90% confidence. Since the entire interval is below

the value of three, support for the hypothesis claim is indicated.

Also, for Survey Question Number 10, the shaded region extends up from

the lower bound value of 3.37 to 5, the highest possible response.

Thus, support for the hypothesis claim is shown. However, the interval

for Survey Question Number 7 extends from the minimum possible value of

1.0 up to 3.6. Since the interval includes the value of three, support

for the hypothesis claim is not indicated. So, Figure 17 and Figure 18

provide snapshots of the data now available to conduct the major tests of the hypothesis claims.

General Findings. A discussion of general findings will be reserved until after the test of the hypothesis claims is conducted. The reason for the delay is because the researcher believes that the data needs to be taken as a whole, rather than discussing each bit of information separately. For this reason the hypothesis test, discussed below, was developed.

The Hypotheses Tested. Table 14 shows the results of filling in Chapter III's Table 9 information. The results indicate that the test ratio, determined by dividing the sum of the chi-squared contributions by the number of survey questions used to test the hypothesis, is less than 0.5 for both the Communication hypothesis and the ECP Submissions hypothesis. However, the test ratio is greater than 0.5 for both the Personnel Resources and TCM Preparation hypotheses. Findings from these results will now be summarized.

Findings. Although the selection of the critical ratio was arbitrary, at least now the major problem areas in the ACM SPO ECP process have been highlighted. Namely, people tend to feel as though they lack the time to review ECPs and provide comments by the date requested. Furthermore, OPRs feel as though they need to go to the reviewers to ask for ECP comments, indicating that they believe the reviewers are not responsive to the suspense, for whatever reason. Additionally, strong support exists for the assertion that people are not taking the time to review TCPs and attend TCMs. Indeed, by focusing more on this area, perhaps a vast improvement could be made to the

TABLE 14

THE END RESULTS OF THE TESTS OF THE HYPOTHESES

	MR Needed to Support Claim	MR	Points Awarded For				Max Score
			LGM	HGM	Intvl	Iden	
Survey Question 1	MR < 3	0	0	0	0	0	0
Survey Question 2	MR < 3	0.15	0.10	0	0.45	0	0.70
Survey Question 3	MR < 3	0	0	0	0	0	0
Survey Question 4	MR < 3	0	0	0	0	0	0
Survey Question 5	MR > 3	0.15	0.10	0.15	0.45	0.15	1.00
Hypothesis I Ratio: (Sum of SQs 1 - 5) / 5 =							0.34
Survey Question 6	MR < 3	0.15	0.10	0	0.45	0	0.70
Survey Question 7	MR < 3	0	0.10	0	0	0	0.10
Survey Question 8	MR < 3	0	0.10	0	0	0	0.10
Hypothesis II Ratio: (Sum of SQs 6 - 8) / 3 =							0.30
Survey Question 9	MR < 3	0	0.10	0	0	0	0.10
Survey Question 10	MR > 3	0.15	0.10	0.15	0.45	0.15	1.00
Hypothesis III Ratio: (Sum of SQs 9 & 10) / 2 =							0.55
Survey Question 11	MR < 3	0.15	0.10	0.15	0	0.15	1.00
Survey Question 12	MR > 3	0.15	0.10	0.15	0.45	0.15	1.00
Hypothesis IV Ratio: (Sum of SQs 11 & 12) / 2 =							1.00

timeliness of the ECP process by virtue of a reduction in the frequency at which ECPs must be processed through the OPR Approval process step, for example.

Chapter Summary

In this chapter the results obtained from performing the steps outlined in Chapter III were presented. Briefly, the researcher determined that four of the ECP timeliness focus questions had yes

answers. Namely, the overall process was found to be taking too much time; specific process steps were found to be more untimely than others, including the process steps from TCP Receipt to TCM, TCM to ECP Receipt, CCB to GD/C Response, Response to Contractual Review Complete, and OPR Approval to OPR Approval to Contractual Review Complete; ECPs are being routed through process steps more than once; and the ideal path flow's average processing time was the only process flow path that clearly took less time on average than the times stated in the CMP. However, the answer to the fifth timeliness focus question was no, indicating that the open ECPs were not distributed disproportionately. Furthermore, the survey responses indicated a lack of personnel resources (in a generic sense) and a lack of TCM preparation and attendance as barriers to process timeliness, while communication and ECP documentation were not indicated as problem areas. With these results and findings, the researcher will now provide a general summary of the thesis effort, state the major findings, and conclude this report with recommended courses of action.

V. Conclusions and Recommendations

Conclusions

In summary, the ECP process in the ACM SPO has been found to be untimely with respect to the Configuration Management Plan. Furthermore, the overall untimeliness is related to one major factor.

The Major Factor. The major factor to the SPO's untimely ECP processing is the lack of effort applied before and during the TCM, as the following discussion explains.

Symptoms of Problems. First of all, specific process steps are taking too long to accomplish. These process steps include the TCP review effort in the SPO (three weeks instead of two), the ECP preparation effort that takes place after the TCM (nine weeks instead of five and one-half weeks), and the steps between the CCB and receipt of the contractor's response (31 days instead of 17 days). This untimeliness is a problem with respect to the ability of the SPO to process ECPs in an overall manner of timeliness; however, the untimeliness of these steps is a symptom of the real problem. Another symptom of the real problem is the frequency which certain process steps must be re-accomplished, including the edit, submittal, and approval steps. Indeed, each of these steps must be accomplished at least twice for each ECP that is Approved with Comments at the CCB; recall that 90.4% of the ECPs that eventually receive government approval are Approved with Comments the first time they are presented to the CCB. This level of rework also could be causing people to feel as though they do not have enough time

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to effectively review the ECPs for which they are responsible for reviewing--the third symptom of the real problem.

The Real Problem. Just what is the real problem? The real problem is that the ACM SPO personnel are not devoting adequate up front effort to the TCP Review and TCM process steps. This problem impacts the ability of the SPO to approve ECPs the first time they are presented at the CCB. Furthermore, due to the requirement for the additional paperwork needed to process these Approved with Comment ECPs, the people feel overworked and. possibly, frustrated. Also, by aggressively reviewing TCPs, the frequency of Approved ECPs could increase, resulting in the elimination of the 57 days that the process takes between the CCB and OPR Approval process steps. Then, the workload would diminish and SPO personnel would then perhaps have more time to devote to better and better reviews of the documentation. However, the ACM SPO must realize the impact an inadequate TCP review process has on the SPO, which leads to the first recommendation.

Recommendations

Education. The first recommendation is to educate the SPO personnel regarding the necessity for an adequate TCP review. By spending the time to review the TCP for not only content but also typographical errors, the SPO may be able to cut down the ECP processing time by simply improving the percentage of ECPs that are Approved, as written. Doing this will reduce the frequency of ECPs that need OPR Approval after the CCB. Recall that the only other process flow that approached the timeliness required by the CMP was the one that did not include TCP Review and TCM process steps. Indeed, if the people in the

SPO do not take the time to really study the TCP, but instead adopt the philosophy that they can catch any errors in content or documentation during the ECP review, then the SPO should abolish the TCP and TCM concept altogether. Otherwise, the only impact these steps will have on the timeliness of the process will be to increase it by the 93.3 days (the CMP calls for 52 days) that the SPO has been averaging between TCP Receipt and ECP Receipt. Furthermore, by improving the frequency of Approved ECPs, the amount of effort required to process the changes and revisions of the Approved with Comments ECPs will be diminished. Thus, people may then begin to feel as though they have more time to adequately review the documents floating across their desks. Indeed, the steps that are required to re-accomplish specific process steps provide the biggest single impact to process timeliness: it took on average approximately 74 days to conduct the second TCM after the first one was held, ECPs that were Approved with Comments took another 57 days between the CCB and the OPR approval steps, and ECPs that had to go through the OPR Approval step a second time took an extra 51 days to get processed.

Emphasis. The second recommendation is for management to place a greater emphasis on the need of the SPO personnel to take the time to adequately review TCPs. This greater emphasis could be accomplished simply by setting up a program to reward OPRs, and reviewers, for reviewing TCPs so well that the ECPs can be approved without comments at the CCB. In fact, even an extra week of review before the TCM and CCB, if necessary, would be in order especially if it meant one less ECP that had to be approved with comments. Thus, the minimum recommended course of action is for the SPO to begin keeping track of the ability of the

OPRs and reviewers to present flawless ECPs at the CCB. An additional step is to set up an awards program to reward those personnel who have been able to cut down the number "Approved with Comment" ECPs. However, this awards program would have to temper the OPRs from becoming advocates of the proposal simply for the purpose of improving their and their reviewers' approval track records. Of course, it is hoped that the reward program would not cause this kind of activity; however, if it does, it could still produce quality decisions if the CCB players adopt certain roles. The chairman would retain his role as the decision maker. The OPR could be the advocate for the change, and the board members, either specific individuals or the entire group, could play the role of antagonists to the change. Who plays the different roles is not that important; however, that someone is playing opposing roles is important.

Training. The third recommendation is to ensure that all personnel who review TCPs and ECPs understand what they should be looking for, and, if they find concerns, how they should attempt to resolve those concerns. Indeed, any actions to improve the ability of the SPO personnel to perform their duties is warranted, especially in regards to the ECP process. The CPIT has recommended a training program be established; this researcher does not disagree with the recommendation of that team.

Tracking. Finally, the SPO must be able to track its progress toward imp vement in the timeliness of the ECP process. The methodology presented in this thesis should be performed once every six months. The result would be detailed information which, when compared to the

results tabulated in Chapter IV, would indicate whether or not the time-liness of the SPO's ECP process is improving. If time and personnel constraints limit the SPO from performing all of the steps presented in Chapter III, then the SPO should concentrate first on the frequency that ECPs are approved with comments, next on the timeliness of individual process steps, then on the simple average processing time, and last on the individual process flow path times. Also, the SPO could compute and compare only the average times, neglecting the variation of the data; however, the statistical accuracy of the findings would be reduced. Finally, the SPO should keep asking itself whether or not it is devoting time to the TCP Review and TCM process steps.

Recommended Future Research

Research the Contractor's Process. This study effort was primarily aimed at the ability of the ACM SPO to process its ECPs. However, some of the findings indicated untimely process steps that required major activity on the part of the contractor. A study should be conducted to determine the proper number of personnel the contractor needs to prepare TCPs, ECPs, CCPs, etc., and cost volumes for ECPs and CCPs. The major hypothesis for this study should be that the contractor does not have sufficient personnel resources to handle the workload. However, the contractor's real workload could be significantly reduced if the recommendations included in this thesis are carried out and a higher percentage of ECPs are approved as written at the CCB.

Research the Time Requirements. A major assumption of this thesis is that the CMP provided processing times which could be used as standards. Perhaps the times stated in the CMP are unreasonable.

Indeed, DOD-STD-480A does not provide definite time constraints. A study, conducted within Aeronautical Systems Division or perhaps within Air Force Systems Command, that focused on ECP time requirements, and the potential ability of organizations to meet them, could provide useful results.

Future Efforts Within the ACM SPO. In addition to performing time assessments, the ACM SPO could sponsor or conduct a future study that would include the analysis of a survey. This survey would need to be prepared so that it would not have problems with validity. as did the survey conducted by the CPIT. The survey could measure the SPO's feelings about how well the ECP process is functioning, whether or not effort is being applied toward the TCM, whether or not the workload is increasing or decreasing, etc.

Summary

In summary, this thesis has provided statistical evidence of an untimely ACM SPO ECP process. Furthermore, evidence was presented which points to the major problem of a lack of effort on the part of people in the SPO to review the TCP and attend the TCM. This problem could perhaps be reduced through the adoption of an awards program which recognizes groups of individuals for presenting high-quality ECPs at the CCB. Finally, the ACM SPO and others are encouraged to expend the effort needed to analyze the ECP process at other organizations.

Appendix A. Roles of ACM SPO Functional Organizations

The following are brief descriptions of the roles the functional

organizations have in the ACM SPO. The following does not include the

roles of the Projects, Dual Source, or Configuration Management

Directorates; their roles are discussed in Chapter II.

Manufacturing Management Directorate (VCD).

Manufacturing is responsible to the director for managing all
manufacturing activities involved in the acquisition. To develop
a product that is in harmony with the program objectives, manufac-
turing performs vital functions throughout the life cycle of the
weapons system. (19:13)

Engineering Directorate (VCE).

The Engineering Directorate provides technical advice to the PM
[Program Manager, or Program Director] and manages the system
engineering function, including system and subsystem integration
and specialties engineering (reliability, maintainability, etc.).
It provides system program technical direction to the contractor
and assures the technical compatibility of all system elements--
it's the Government's equivalent to the contractor's engineering
organization [and] provides engineering "doers" as well as the
contractor engineering management "watchers." (19:11)

Safety Directorate (VCF). VCF oversees all systems safety

responsibilities for the program, including any safety issues pertaining

to the current and future development, deployment, operation, or

maintenance of the hardware (16).

Contracts Directorate (VCK). The contracts directorate manages

all acquisition activities of the SPO, especially those of a contractual

nature between the government and the contractor (19:13).

Integrated Logistics Support Directorate (VCL).

This directorate is ... jointly manned by AFLC [Air Force Logis-
tics Command] and AFSC personnel. It provides the PM with logis-
tical/technical guidance and assistance in the areas of relia-

bility and maintainability; maintenance planning; support equipment; supply support; packaging, handling and transportation; technical data; facilities; manpower requirements and personnel; training and training support; logistic support reso···ce f· ·s; logistic support management information; computer ·· ···· support; energy management; survivability; and ILS [Integrated Logistic Support] test and evaluation. (19:12)

Management Operations Office (VCO).

This office provides executive services and support to the [SPO] in functions relating to personnel administration, publications, forms, and reports; training; correspondence; property and supply control; and manpower and organization. (19:13)

Program Control Directorate (VCP).

This directorate is responsible for program planning, programming, progress tracking, status accounting, trend analysis, documentation, and financing. It is the nerve center of the SPO through which the program director maintains management control, surveillance, and understanding of the program. (19:12)

Security Directorate (VCR). The ACM SPO is one of the few SPOs in ASD that has its own professional security specialists on hand to oversee all security issues with respect to the data and hardware associated with the Advanced Cruise Missile (21). One of VCR's major tasks is to keep the Security Classification Guide up to date so everyone who is involved with the program can stay current on the classification of aspects of the program (21).

Test and Evaluation Directorate (VCT). The test and evaluation function is responsible for managing the overall testing effort, including everything from developing system test plans and objectives to making sure test results are analyzed correctly and recommendations for any corrective actions are made and carried out (19:12).

Acquisition Planning Directorate (VCX). VCX's role is to perform the acquisition planning function of the program, including planning for future source selection activity, developing the acquisition strategy,

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integrating the planning activities for future lot buys, and providing the potential view of the future needed to shape the SPO's current activities (12).

SEMCO, ARINC, and TASK. Three other organizations, Systems Engineering and Management Company (SEMCO), ARINC Research Corporation (ARINC), and The Analytical Services Company (TASK), provide technical expertise to the SPO, for a price, through the placement in the SPO according to their specific specialties (16).

Appendix B. The CPIT Survey

The following is an example of the survey administered to ACM SPO personnel by the CPIT. This questionnaire was administered to each person in the SPO who was involved with the ACM SPO ECP process.

ACM CHANGE PROCESS
CRITICAL PROCESS TEAM (CPT)
SURVEY

ECPs GOT YOU DOWN?

IS "EXPEDITE" A FOUR-LETTER WORD?

DO YOU DEFINE OPR
"OBSTINATE PAIN IN THE REAR?"

Herein lies the beginning of improvement. Much of the framework for how and what the CPT attacks will be determined from the results of this survey. Please help us to help you by filling this out honestly and completely. This is a short answer survey to maximize response, however we welcome comments, suggestions, and explanations of your answers, as your time allows.

If you don't know what the CPT is, you'll learn more about it at the January [1990] TQM training. For purposes of this survey, they are a group of ACM (Govt & Contractor) personnel, who are taking a look at the way we process ECPs/CCPs with the goal of making the process easier for everyone involved. The results of this survey will be briefed at the January training.

For your information the following people are assigned to the CPT:

Doug Jones,	Team Leader VCK	Teri Sieck	DCASPRO	GD/C
Dave Parlagreco	VCA	Diana Durdines	SEMCO	
Don Hoyle	VCL	Hal Lewis	ARINC	
Patti Kemper	VCP	Teena Stevens	SEMCO	
Mike Spencer	VCE	Dean Price	OC-ALC	
Marilyn Judd	VCC	Jim Fleming	MDMSC	
Al Link	VCT	Burt Kurz	GD/C	

YOUR NAME IS NOT REQUIRED, BUT WE ASK THAT ALL SPO MEMBERS COMPLETE THE SURVEY AND TURN IT IN TO YOUR POC BY COB 18 DEC 89.

If you don't understand a question or have other questions regarding this survey your 3-letter POC is:

Please check the item below which most correctly describes your PRIMARY role in the ECP/CCP process.

_____ I am the OPR.

_____ I represent my three letter organization on the CCB.

_____ I provide comments to ECPs/CCPs that I am tasked to review.

_____ I am responsible for coordinating/compiling the comments within my three letter organization for our CCB representative, but I am not the CCB representative.

_____ I am involved in the administrative handling of ECPs/CCPs (as either Govt. or support contractor).

_____ I am a support contractor providing review comments to both SEMCO and the Government.

x) Do you feel that you have been adequately trained to fulfill this role. If not, how do you feel you should be trained? In what areas do you feel you need additional training?

x) If you could change one thing about the way a ECP/CCP is processed while it is in the SPO, what would it be?

x) If you could change one thing about the way a ECP/CCP is processed outside of the SPO, either by the contractor or another Government agency, what would it be?

Please rate the following statements by circling the number which most correctly describes you feelings according to the scale below:

1 - This is almost always or always false
2 - This is false most of the time
3 - This is true as often as it is not true
4 - This is true most of the time
5 - This is almost always or always true
6 - This does not apply to me

x) I have adequate time to review ECP/CCPs and provide comments by the date requested. If you don't feel you have adequate time, please write in the amount of time you feel is necessary.

     1   2   3   4   5   6

x) I attend the TCM for all TCPs that I would comment on as ECP/CCPs.

     1   2   3   4   5   6

x)   I work to the CCB date for an ECP/CCP rather than the date comments
are due to the OPR.
                    1   2   3   4   5   6

x)   The Contractor has adequately addressed and documented the ECP/CCP
prior to submitting it to the Government.
                    1   2   3   4   5   6

x)   The CCB is a formality with all possible issues resolved before the
ECP/CCP is boarded.
                    1   2   3   4   5   6

x)   My three letter organization has a single point of contract for all
ECP/CCPs.
                    1   2   3   4   5   6

x)   I am NOT experiencing any difficulty with the timeliness of
companion ECPs.
                    1   2   3   4   5   6

x)   I am NOT experiencing any difficulty with the effectivity of
companion ECPs.
                    1   2   3   4   5   6

x)   The contractor complies with the intent of the TCM minutes.
                    1   2   3   4   5   6

x)   The contractor complies with the intent of the CCB Directive.
                    1   2   3   4   5   6

x)   I go to the OPR to get my questions answered regarding an ECP/CCP
prior to submitting my written input.
                    1   2   3   4   5   6

x)   I am informed of concessions/changes made to an ECP/CCP during
negotiations that impact me.
                    1   2   3   4   5   6

x)   My three letter organization disseminates ECP/CCPs to the proper
individuals and then forms a coordinated position for submittal to the
OPR.
                    1   2   3   4   5   6

x)   The SPO has informal, but consistent, guidelines for performing the
technical evaluation of ECP/CCPs.
                    1   2   3   4   5   6

x)   I give the OPR an opportunity to resolve any issues I have prior to
the CCB.
                    1   2   3   4   5   6

x) The contractor implements TCM minutes/CCB directives as agreed/directed.
         1   2   3   4   5   6

x) I know how to find out the status of an ECP/CCP within the SPO.
         1   2   3   4   5   6

****

The following statements apply to ECP/CCP OPRs. If you have never been the OPR for an ECP/CCP, skip to the last section.

x) I am aware of all issues prior to them being raised at the CCB regarding my ECP/CCPs.
         1   2   3   4   5   6

x) I prefer that reviewers contact me to have their issues resolved regarding my ECP/CCPs.
         1   2   3   4   5   6

x) I receive coordinated comments by the date requested from each three letter organization.
         1   2   3   4   5   6

x) I know what the established SPO procedure for margin submittal and approval is.
         1   2   3   4   5   6

x) I have to go the functionals and personally ask for their comments in order to compile then for CCB.
         1   2   3   4   5   6

x) The CCB Representatives ask questions at the CCB that have already been resolved with their working people.
         1   2   3   4   5   6

x) I am comfortable with the negotiations process.
         1   2   3   4   5   6

x) I receive substantiated tech evals from the functionals.
         1   2   3   4   5   6

x) I receive timely tech evals from the functionals.
         1   2   3   4   5   6

x) I receive comments from functionals on ECP/CCPs who did not attend the TCM where they could have been resolved.
         1   2   3   4   5   6

x) I receive questions from the functionals rather than statements.
         1   2   3   4   5   6

x) Some functionals consistently submit the same comments to me on every ECP/CCP.

                  1   2   3   4   5   6

x) Write in Answer: How many days prior to the CCB do you usually have comments from all functionals? _____ days

****

Each of the preceding statements addressed an issue. If you could set the priorities of the CPT, which issues (by statement number) would you have them address first:

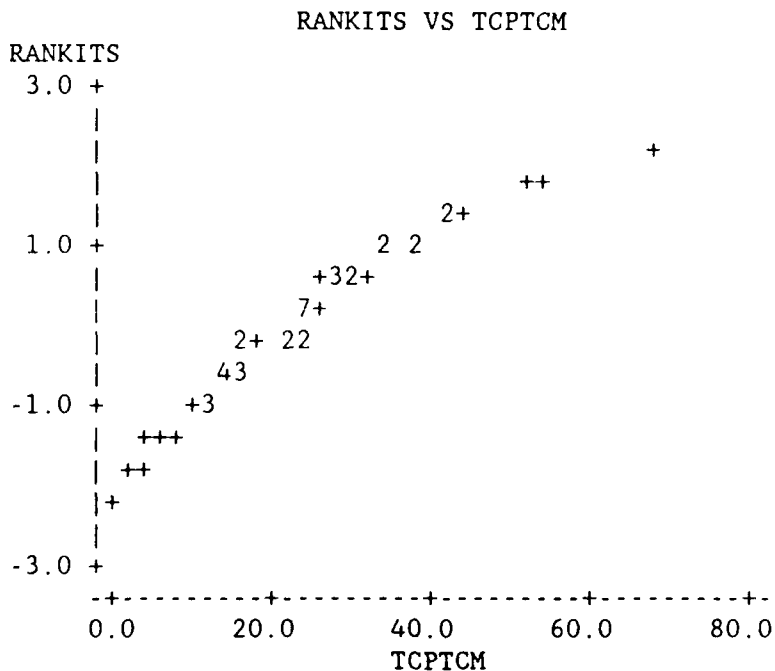Priority 1:_____   2:_____   3:_____

****

Please use the remaining space to annotate any additional concerns, comments, etc. Attach additional sheets as required. Thank you for your help.

Appendix C. Output from the Tests for Distribution Shape

In this appendix are the outputs from the Statistix and MathCAD computer programs. These outputs are examples of the statistical examinations that were performed to assess the distribution shape of the data, whether normal or exponential.

Test for Normal Distribution

The first test was to determine if the data followed the normal distribution. The set of times was entered into Statistix and the Wilk-Shapiro test for normality was invoked (22:8.4-5). The result was a plot and a calculated Shapiro-Francia statistic, as shown below for the set of times between TCP Receipt and TCM:

```
                        RANKITS VS TCPTCM
      RANKITS
        3.0 +
            |
            |
            |                                  +
            |                          ++
            |                   2+
        1.0 +              2  2
            |           +32+
            |            7+
            |         2+ 22
            |        43
       -1.0 +      +3
            |   +++
            |  ++
            |+
            |
       -3.0 +
            -+---------+---------+---------+---------+-
           0.0       20.0      40.0      60.0      80.0
                              TCPTCM
```

APPROX. WILK-SHAPIRO 0.9478   49 CASES PLOTTED

145

The plot above shows an approximately straight line, and the approximate Wilk-Shapiro statistic is greater than 0.90, so this set of data is indicated as normally distributed. However, if the line was not straight and if the approximate Wilk-Shapiro number was not greater than 0.90, then the test for the exponential distribution was employed.

Test for the Exponential Distribution

The MathCAD output is included on the following four pages. Basically, by entering a set of process times, in this case for the time between the second CCB and receipt of the edited ECP, in the form of a vector, MathCAD can be used to produce not only a histogram of the data but also the adjusted K-S statistic value. The MathCAD output is documented, so brief summaries of the steps of producing the histogram and the K-S statistic follow.

Histogram. First, we set up the BINS, which are the boundary values of the histogram intervals (1:101). The minimum value of BINS is the smallest value in the "vect" vector, and the highest boundary value is equal to the highest value in "vect" (1:101). The "hist" function is then used to count up the number of data elements from "vect" that are within each of the BINS boundaries (1:102). Dividing the number of elements within each of the boundaries by the total number in "vect" produces a percentage which can then be compared to the theoretically determined percentage calculated as "Ffit." Furthermore, by plotting the theoretical and empirical percentages, a preliminary test of the distribution can be conducted (1:103). Figure C-1 shows how the empirical data tracks to the theoretical values. Next, we perform the K-S test.

<u>K-S Test</u>. The MathCAD output documents the steps involved in computing the adjusted K-S test statistic value. The output also shows, for a range of significance levels, the K-S critical values. The calculated values must be less than the critical values if the data can be considered as following the exponential distribution (20:195). A figure also is provided which shows the empirical and theoretical cumulative density functions, providing a visual comparison of the goodness of fit between the two cumulative density functions.

<u>Summary</u>

The tests of the distribution shape were performed in this manner whenever an assumption about the shape of the data's distribution shape was made.

Test for an exponential distribution.

"vect" is the set of process times for
the those ECPs that were approved with
comments at the second CCB.

$$vect := \begin{bmatrix} 1 \\ 6 \\ 9 \\ 20 \\ 21 \\ 49 \\ 51 \end{bmatrix}$$

The sample statistics are:

N = 7
mean = 22.429   the sample mean
pvar = 348.531   the population variance
svar = 406.619   the sample variance
ssd = 20.165   the sample standard deviation

First, we set up a histogram of the data to look at the
general shape of the data. If it appears to be exponential,
we press ahead with the Kolmogorov-Smirnov test.   The
procedures for developing the histogram were taken from the
MathCAD User's Manual (1:100-108).

$x := 1\ ..max(vect)$ $\lambda := \dfrac{1}{mean}$ $f(x,\lambda) := \left[\lambda \cdot e^{-\lambda \cdot x} \right]$

$f(x,\lambda)$ is the equation for
the exponential distribu-
tion, for x > 0.

n := 3   number of intervals
I := 0 ..n   Index
MIN := min(vect)   first interval
MAX := max(vect)   max interval $j := 0\ ..n - 1$

$$BINS_I := MIN + I \cdot \frac{MAX - MIN}{n}$$

$$BINS = \begin{bmatrix} 1 \\ 17.667 \\ 34.333 \\ 51 \end{bmatrix}$$

FREQS := hist(BINS,vect)

$$\frac{FREQS}{N} = \begin{bmatrix} 0.429 \\ 0.286 \\ 0.143 \end{bmatrix}$$

$$Ffit_j := \int_{BINS_j}^{BINS_{j+1}} f(y,\lambda)\ dy$$

$$Ffit = \begin{bmatrix} 0.501 \\ 0.239 \\ 0.113 \end{bmatrix}$$

0.6

FREQS
$$\frac{FREQS_J}{N}, Ffit_j$$

0
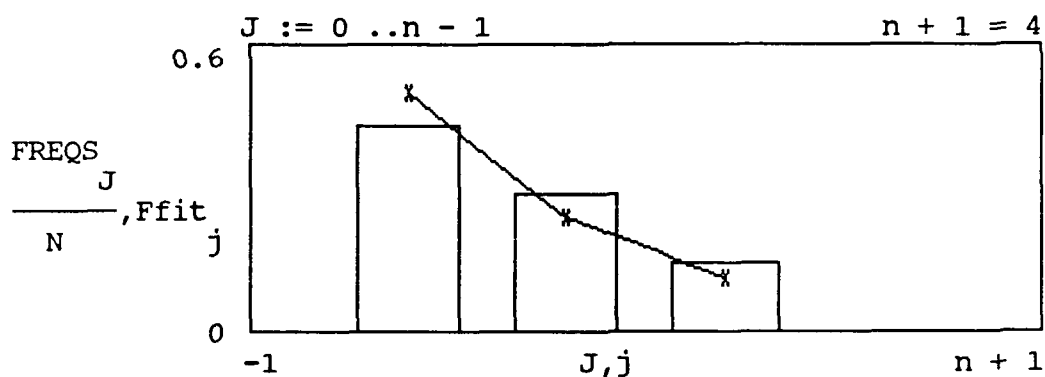   -1   J,j   n + 1

Figure C-1. Histogram of Data

Since the data appears to resemble an exponential distribution,
we now perform the K-S test.

First, we must define an empirical distribution function, F(z),
where F(z) = (# Xi's <= z) / n. Then, we compare F(z) to Ffit
which is the theoretical curve and is computed across the domain
of vect.

THE THEORY   THE EMPIRICAL

$k := 1 ..N$ $l := 1 ..N$
$c_k := vect_k$ $d_l := vect_l$

                              When 1/n is plotted against d.1, then
                              the right-continuous step function is
                              generated (see plot below).

$$Ffit_k := \int_0^{vect_k} f(y, \lambda) \, dy$$

              Ffit is the continuous cumulative density
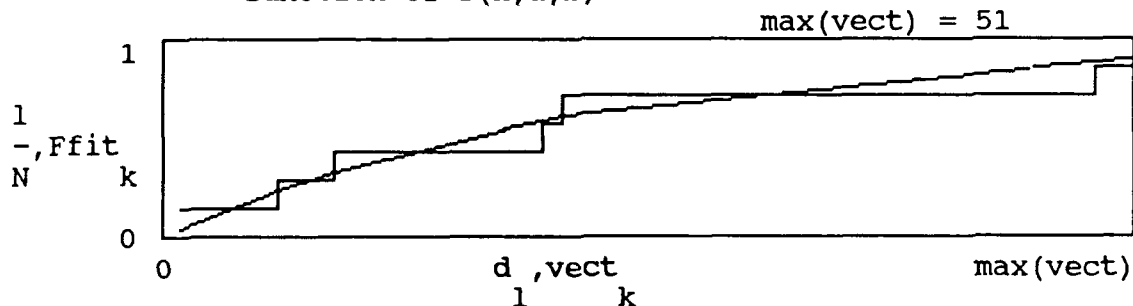   function of f(x,a,b).

                                              max(vect) = 51

1

$$\frac{1}{N}, Ffit_k$$

0
        0                      $d_l, vect_k$ max(vect)

Figure C-2. Plot of Theoretical and Empirical Curves

$$E_k := \frac{k}{N} - Ffit_k \qquad\qquad F_k := Ffit_k - \frac{k-1}{N}$$

min(E) = -0.03   min(F) = 0.036
max(E) = 0.106   max(F) = 0.173

maxD := .173   Suprema Maximum: the highest of the
                absolute values of the four numbers
                above.

The calculated K-S statistic for testing for an exponential
distribution is calculated from the equation below:

$$\left[maxD - \frac{.2}{N}\right] \cdot \left[\sqrt{N} + .26 + \frac{.5}{\sqrt{N}}\right] = 0.447$$

K-S critical values for exponential distribution are:

equal to   0.926   0.990   1.094   1.190   1.308

for (1-α) values of   0.850   0.900   0.950   0.975   0.990

Since the calculated K-S statistic is LESS than the critical
value for a significance level of 0.90 listed above, we can
conclude that the data indicates an EXPONENTIAL fit.

The parameters for the data are:

λ = 0.045
mean = 22.429
ssd = 20.165

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<u>Vita</u>

Captain Jeffery S. Robertson was born on 12 December 1961 in Bangor, Maine. He graduated from MacArthur High School in San Antonio, Texas in 1980 and attended Texas A & M University, graduating with a Bachelor of Science in Mechanical Engineering in August 1984. Upon graduation, he attended the Air Force Officer Training School in San Antonio, Texas where he earned his commission in the USAF on 30 November 1984. He served his first tour of duty at Wright-Patterson AFB, Ohio, where he first was assigned as a program analyst for the acquisition of various airlift systems including the MC-130H, C-5B, and others, until he was chosen to be the program analyst for the C-17. He served in the C-17 System Program Office (SPO) until 15 November 1986, where he was recognized as Aeronautical Systems Division's Outstanding Program Analyst for 1986. He was then assigned to the Advanced Cruise Missile (ACM) SPO, where he was the Retrofit Manager and the Radar Cross Section Manager until he was chosen for a six-month assignment as the ACM SPO Director's Executive Officer, a duty he performed until January 1990. He then resumed his role as the Retrofit Manager through March 1990, when he attended Squadron Officer School (SOS). His return from SOS to the SPO was short lived, since in May 1990 he entered the School of Systems and Logistics, Air Force Institute of Technology.

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13. ABSTRACT (Maximum 200 words)

This study investigated the engineering change proposal (ECP) process in the Advanced Cruise Missile System Program Office (SPO). Specifically, efforts were geared toward verifying a problem with the timeliness of the process and identifying the specific problems leading to untimeliness. Also, a survey questionnaire was analyzed to assist in the development of conclusions about the problems with the ECP process. The major conclusion was that the personnel in the Advanced Cruise Missile SPO were not taking advantage of the opportunity to review a preliminary copy of the ECP, called a Technical Change Package (TCP). By doing so, the SPO could have produced better quality ECPs which the approval authorities perhaps could have approved as written. However, because of content and documentation errors, the ECPs had to be deferred or approved with comments. These ECPs that were approved with comments required additional process steps which added significantly to the amount of time required for eventual approval. The recommendation was made for the SPO to educate the personnel about the importance of an adequate TCP review, encourage improvement through the adoption of an awards program, and take steps to educate those personnel in the SPO who need training.

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